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W. R. Woolrich, President, A.S.E.E., 1952-53

About 45 years ago, the son of a retired Wisconsin pioneer dairyman made a bargain with the power plant people of Mineral Point.

He would work for nothing until he learned to operate the plant. And work he did, getting up at 4:30 every morning to fire the plant before school time.

On graduation from high school at 17, he was power engineer for a lead and zinc mining company. (Twenty years later he learned he had been too young to hold such a position because the state law at that time required power plant operators to be 21.)

But came the lightning-like depression of 1907 which claimed mining as one of its first victims. One day he shut down the plant, "laid it by," greased all the machinery, and drained the boilers. The next day he was on his way to Madison where he later received two University of Wisconsin degrees in engineering—mechanical and electrical.

That was the start of W. R. Woolrich, College of Engineering dean, Bureau of Engineering Research director, and professor of mechanical engineering at the University of Texas—and now president of the American Society for Engineering Education.

Dean Woolrich has had an interesting engineering career which includes work in industry, government and education—as a member of a team of engineering educators who helped organize an engineering college at DePaul University; Western Electric Company engineer and International Harvester Company work-shop school director; assistant professor, then professor and chairman of the mechanical engineering department at the University of Tennessee, and later head of the Tennessee Valley Authority's Agricultural Industries Division. He joined The University of Texas faculty in 1936.

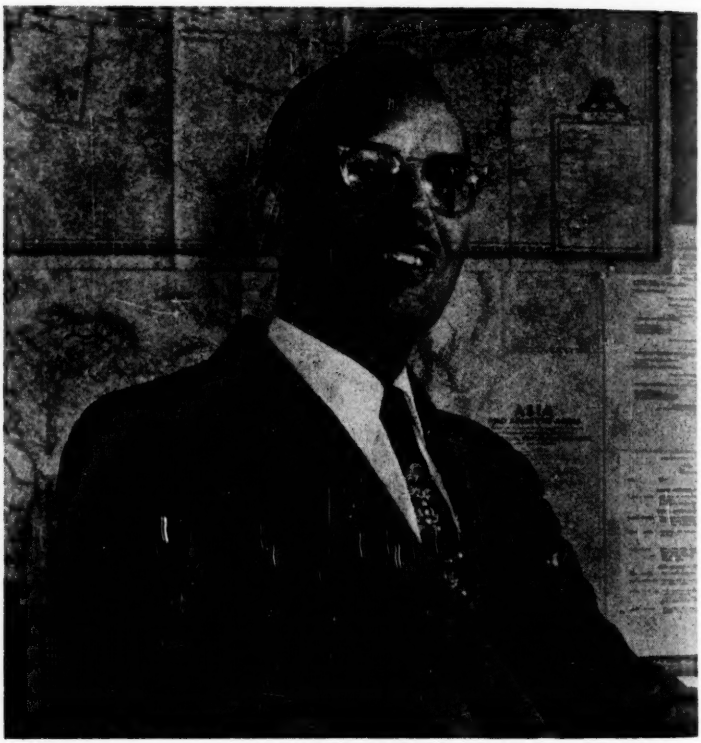
Woolrich's TVA appointment came as a result of work he did with the late Dr. Harcourt Morgan, then University of Tennessee president, developing a program for interspersion of agriculture and industry on the western slopes of the Appalachian Mountains. The plan was incorporated in the Congressional act creating the TVA.

In other government work, Dean Woolrich served as director of a University of Tennessee student army training corps' trade school in World War I, regional advisor and representative in Texas, Louisiana and New Mexico for the U. S. Office of Education in World War II, and chief scientific officer for a U. S. mission to Great Britain in 1948–49 to survey that nation's industry and scientific facilities.

He has been an advisor to the Department of Commerce, and U. S. Government Patents Board, and U. S. representative on the British Fulbright Commission, administrators for the Congress created fellowships and scholarships involving Great Britain.

At the present, he is chairman of a National Research Council committee to improve housing in warmer climates of the U. S. and other parts of the world.

Dean Woolrich is very familiar with the American Society for Engineering Education's background, especially its teaching and research activities. He was president of the Engineering College Research Association in 1946–47 when it completed plans to merge with the Society for Promotion of Engineering Education to form the ASEE. Since then he has served as the ASEE's Southwest Section representative, chairman of its International Relations Committee and its representative on



W. R. WOOLRICH, PRESIDENT

the Engineering Council for Professional Development.

His activities with other professional engineering societies include being national chairman of the American Society of Mechanical Engineers' local sections' activities, and a director, and later vice-president of that organization; a director of the American Society of Refrigeration Engineers; twice chairman of the American Association for Advancement of Science's engineering section; on the National Society of Professional Engineers' educational committee; and, currently, chairman of the Texas Society of Professional Engineers' educational program.

He is the author of several handbooks and publications on engineering.

Although he has many national activities, Dean Woolrich has been diligent at home strengthening the reputation of the College of Engineering at The University of Texas. Standards have been raised, the number of credits necessary for graduation increased, an advisory system for engineering students installed and graduate level work greatly expanded for all engineering departments.

In Recognition and a Forward Look

By W. R. WOOLRICH

President of ASEE, Dean of Engineering, University of Texas

In the roster of associations of the several scientific and engineering professions of both Europe and America, the American Society of Engineering Education has the unique distinction of being the first and most effective organization within any of these professions established specifically to promote and develop improved methods of college and university teaching by the teachers and teaching administrators themselves. For nearly sixty years these college and university teachers of the engineering profession of North America have continued to make constructive and analytical studies of their own objectives, methods and procedures and also periodically to investigate the comparative methods and results of the engineering teaching of other nations.

Within the Society many of us have become so inured to the many activities of the organization that we fail to recognize the importance and the impact of this continuing program of the several Divisions, Sections, Committees, and Councils of the American Society for Engineering Education and its two predecessors from which it was created, viz., the Society for the Promotion of Engineering Education and the Engineering College Research Association. Each of us should pay tribute to this long line of distinguished, competent and devoted teachers of engineering who have made earnest and sacrificial life-time contributions to the art and science of engineering education in North America.

Each new administration that accepts the responsibility of serving the Society is fortunate indeed to inherit such a birthright. The bench marks have been well established from which to project the forward planning.

Some of the activities of committees nurtured by the Society are of a continuing nature and any change in administration should cause no disruption of their effective work in progress. Other functions of the ASEE are under the direction of committees which require annual or biennial changes of personnel by virtue of the authority through which they were created. To provide this change of personnel, yet maintain or increase the effectiveness of the group, is an obligation of the Administration of the Society.

Retiring President S. C. Hollister has recently named two very urgently needed Committees that were authorized by the Executive Board and Council, the one under the leadership of Dr. L. E. Grinter on "The Evaluation of Engineering Education" and the other now being organized under the Chairmanship of Dr. Richard B. Teare on "Improvements of Society Function." The work of these two committees is very essential to the future progress of the Society and their work should result in the development of a more closely knit organization in which all members participate.

Throughout the coming year, by utilizing the general framework of the appointed and established Committees, Sections, Divisions and Councils, may we make it our business to give a renewed emphasis to superior teaching. In the past decade of war years, it has been necessary for many of us to underscore creative research in our colleges and universities, and many of those who have

entered the engineering teaching profession during this ten or twelve year period have found the research enterprise of many departments receiving more recognition than the teaching of the engineering students. Research in itself should be one of the fountain sources of inspiration by which the teacher reinforces himself in his teaching preparation, and our research and administrative contributions should be maintained as complimentary to the major obligation of doing effective inspirational teaching and not in competition with it.

Very closely integrated with this goal of improving our classroom teaching is the timeliness of re-affirming our philosophy of engineering ethics by taking a strong position with the professional engineering societies in requesting them to join with us in pronouncing again the CANON OF ETHICS OF THE ENGINEER as the creed of the professional engineer. Under the disrupting influence of wars, cracks have developed in the moral integrity displayed by a few in our profession, especially in their engineer-contractor, engineer-architect, engineer-salesman or even engineer-client relationships. By its very nature, engineering cannot afford even microscopic cracks in its structure if it would build for a better profession of tomorrow. This administration will accept it as one of the duties of the office to obtain cooperation of the professional engineering societies in this re-emphasis on integrity in all channels of engineering enterprise, but a re-enforced front all along the line of our several committees and in our classrooms in which we again express a new zeal for plain honesty, forthrightness and morality will be most compensating.

To meet the urgent need that the universities provide North America and many other areas of the world with more engineers with top level, scientific education is a real challenge to all graduate level engineering colleges and universities. It should be a matter of deep concern to all of us in America that a disproportionate number of the best educated and trained engineers of the world came from European and British universities up to the advent of World War II. With the restoration of Europe, much of this leadership in advanced fundamental engineering science can be expected to be claimed again by the scientific educational centers of Western Europe if we of America cannot meet the need.

The future pattern of American engineering education will probably call for a large number of men with diplomas from the technical institutes, a somewhat smaller number who will reach the level of their best usefulness and service at the baccalaureate level, still a smaller select group who should receive instruction through the Master's level, then a highly selected group who should receive instruction by organized programs designed to carry men through the doctorate and post doctorate to possible levels far in excess of anything we have attempted on this side of the Atlantic to the present day. The building up of a very high level scientific and engineering educational system within North America for a selected portion of our capable candidates is even of greater importance than that we meet the growing deficiency in numbers of capable engineers at the baccalaureate grade.

Those who wrote the present Constitution of the American Society for Engineering Education were desirous of emphasizing that this was a society of engineering educators from the American Continent. From earliest days of the Society for the Promotion of Engineering Education the engineering teachers of Canada have been active participants. In fact, the Fifth Annual Meeting of the SPEE was held at the University of Toronto and the 39th at McGill University.

As a Society let us not overlook our great opportunity to establish closer bonds of professional fellowship with those teachers in our own profession in South America, Great Britain, Europe, and Asia. There is much evidence that the time is appropriate for us to invite closer cooperation in engineering education between the engineering schools of North America and those established in other

areas of the globe. We in North America have been the recipients of much of the scholarly work in science and engineering of Great Britain and Europe for over two hundred years. Some of the finest contributions made to engineering education in the United States came from our members who received their initial education and inspiration from British and European universities. In this as in other international relationships we will profit most by giving most.

Reserve this date . . . .

June 22-26, 1953

ANNUAL MEETING

UNIVERSITY OF FLORIDA

GAINESVILLE, FLORIDA

In the News

Eight members of the 24-member National Science Board of the **National Science Foundation** whose initial two-year terms expired on May 10, 1952, have been reappointed by the President for full six-year terms, ending May 10, 1958.

Following is a list of members of the Board receiving reappointments: Sophie D. Aberle, Special Research Director, University of New Mexico, Albuquerque, New Mexico; Robert P. Barnes, Head, Department of Chemistry, Howard University, Washington, D. C.; Chester I. Barnard, Chairman of the Board, and retiring President, Rockefeller Foundation, New York, N. Y.; Detlev W. Bronk, Chairman of the Executive Committee of the Board, President, The Johns Hopkins University, Baltimore, Maryland; Gerty T. Cori, Professor of Biological Chemistry, School of Medicine, Washington University, St. Louis, Missouri; Charles Dollard, President, Carnegie Corporation of New York, New York, N. Y.; Robert F. Loeb, Bard Professor of Medicine, College of Physicians and Surgeons, Columbia University, New York, N. Y.; Andrey A. Potter, Dean of Engineering, Purdue University, Lafayette, Indiana.

A Goal for American Engineering Education*

By S. C. HOLLISTER

Dean of Engineering, Cornell University

During the past two years this Society has been deeply concerned over the shortage of engineers which became apparent about three years ago. This shortage is deepening in accordance with earlier predictions, and will not reach its lowest point for another year or two.

The situation has raised many important questions relating to overall manpower of the nation. That we are engaged in a vast technological struggle is generally recognized. At the same time, the technological character of our economic and social system is at the highest point in history, and is continually accelerating. Overlying these is the urgent necessity for men in military service. As a people we have become accustomed to the mistaken idea that the source of America's strength is inexhaustible. Some are now beginning to realize that, as with strategic materials, there is a limit not only to manpower itself but also to various categories of capacities and abilities of men. There is a limit to what we may expect from campaigns to solicit more engineering students from among the high school graduates. In turn there is a limit to the number who may graduate from high school. And there are other learned fields to be serviced besides the field of engineering.

A Limit to the Source of Supply

At various regional meetings during the past year I have spoken about the likely limits of flow from high school into the engineering colleges. If we assume that the intelligence level for the learned professions lies above an I.Q. somewhere between 115 and 120, we find that 120,000 males of a given age group, say 18, are available for annual entry into these fields. This number of youth must supply medicine, science, engineering, law, theology, and the upper levels of the teaching profession. The number must be discounted to allow for those who are lacking in ambition, emotional stability, perseverance, physical fitness, or economic means. It would appear that under normal circumstances less than 40,000 freshmen may be expected annually to enter the engineering schools. Thus the number of males of a given age group having an intelligence level suitable for the pursuit of engineering study is a fixed percentage of the age population, a percentage which we have reached in our current freshman enrollment of 38,000.

If by artificial stimulation a larger number than 40,000 is persuaded to enter engineering schools it will probably be at the expense of enrollments in the other learned fields. It must be remembered also that to some extent a number of schools are admitting students possessing a lower intelligence level than 115 to 120. They will be successful or not, academically, in accordance with the level of the program in such schools.

Need for Engineers Increasing

Surveys indicate that the present need of industry and other agencies for engineers is of the order of 80,000. The number of engineering graduates this year and in several coming years being 20,000 or less, it is clear that we are markedly short of meeting the need. It must further be

* Presidential Address, ASEE Convention, Dartmouth, 1952.

recalled that with the operation of the present R.O.T.C. and other military programs, substantially more than half of the engineering graduates may go directly into military service for two or three years at least, during which time they will for the most part not be used in technical work. They would be available to industry only after return from service, by which time their training will have been dulled to some extent due to technical inactivity.

Assuming that we are in an international situation which will persist for many years, it becomes clear that continuity of education at least for all of the specialized personnel necessary for our social, political, economic and military system must continue in full force. The present Selective Service policy is clearly based upon this concept. It is placed in jeopardy, however, by the mistaken concepts in the public mind relating to democratic practices. It is thought to be democratic, for example, only if all boys of age 19 at once enter military service. It is overlooked that in addition to equal obligation for service each man should serve in his maximum capacity. It is overlooked also that a democracy must have leaders at all levels, and that people capable of leadership in a democracy have an obligation to exert such leadership. All of these misconceptions are also endangering sound policy relating to the training of leaders which is, or at least should be, the prime concern of our institutions of higher education.

According to the census there was one engineer to about 250 workmen at the turn of the century; today there is one engineer to about 50 workmen. As industrialization has intensified, the number of engineers necessary to operate the system has rapidly increased. However, it should be noted that this increase is not going to continue, since as described earlier, the number of freshmen normally entering engineering is a fixed percentage of the age population, and this percentage is not likely to increase. Thus the increase of engineers as percent of the population has reached a stopping point.

We have not reached a stopping point, however, in the increased need of engineering services in our modern economy. In fact, as it becomes more and more complex, the number of engineers needed is constantly increasing. At the same time, the level of knowledge of the engineer is constantly advancing. This gives rise to the need for some study of the engineering profession itself—how it is constituted, and how it renders its service to society.

Reorganization of Professional Function Necessary

According to the census, there are approximately 450,000 engineers in the United States. This is more than double the number of scientists or doctors. Why this great difference?

The medical profession has long since had the services of nurses, therapists, laboratory technicians, and others trained in the support of operations surrounding the work of the doctor. Thus the health service is directed by the doctor, but is furnished by the entire group working as a team. The same is true with the service of the scientist, who is supported by mechanicians and laboratory technicians of a wide variety.

In the engineering profession, however, many college graduates get no further than the junior positions in the profession, or are utilized in peripheral activities relating to, but not a part of, the profession itself such, for example, in salesmanship, advertising, marketing, etc. Some personnel from trade schools or from technical institutes serve as engineering aides in the drafting room, laboratory and field, but their numbers do not bear the proportion to the number of engineers that would be true, for example, of aides in the medical profession.

In industry there is a tendency to use the junior engineer in a wide variety of services for which engineering training is admittedly good, but not absolutely essential. Furthermore, so long as the supply in the past has held up at a good level

it has been possible for employers to continue the use of these men in junior positions for longer periods than would be justified in terms of their training and experience.

As matters now stand it appears that we have reached a turning point in the profession. With the percentage of the population to be made into engineers no longer on the increase, but with the amount of engineering service needed in the economic system constantly accelerating; and moreover with the evidence of the disparity of these two situations abundantly evident before us, it now becomes clear that a complete reorganization of the profession must take place over the next few years if the engineering work of the future is to be achieved at the level demanded by our economic system.

It also becomes clear that in this gradual readjustment three major factors will have to be given special attention:

1. the training of more aides to support the engineers;
2. the change in practice of utilization of engineers by industry and other agencies employing them; and
3. the education of the engineers themselves.

It is this latter consideration that is of prime concern to us as members of this Society.

Problems in Engineering Education

The Engineers' Council for Professional Development, in a report on Adequacy and Standards of Engineering Education, calls attention to the fact that in most engineering colleges the curricula in at least civil, mechanical, mining, and electrical power engineering have not changed materially in the last forty years. The Council views this as evidence that the curricula in these fields are not keeping abreast of professional and industrial demands. This report was referred to this Society for its immediate consideration. It has been published in the Journal.

Prior to World War II a number of engineers trained in Europe were from time to time taken into industry and into the colleges to strengthen our engineering staffs. Since the war there has been a considerable number of these European engineers who have come to this country. Those trained on the continent were trained under a system in which the work for the first degree was equivalent to about one year beyond the master's degree in most American engineering schools. With such training they stand out spectacularly in our engineering staffs and have made significant contributions.

The introduction of European trained personnel is not peculiar to the engineering profession. In the fields of mathematics, physics and chemistry are to be found many scientists trained abroad. Prior to World War II it was common practice to send many of our American students to be further trained in Europe, particularly in Germany. With the disruption of European education brought about by World War II this practice has practically stopped.

Dr. Wickenden, in his famous report on engineering education made to this Society in 1929, said at that time: "Technical research has depended in large measure on men of European training or upon men trained in pure science. These conditions are gradually being corrected, but American engineering is still far from being self-sufficient on its higher intellectual levels." In the twenty years since that statement was printed the situation has not materially changed, except in isolated areas.

Many engineering educators who might have undertaken to stimulate membership in technical societies from among their students have heard the remark by these students that they find little that they can understand in technical literature published in the Society *Transactions*. To the extent that this may generally be the case among our engineering graduates, it represents correspondingly the extent to which our graduates may not be able to keep abreast of future developments as they occur. If they cannot understand the literature that is at present current, how are

they to keep abreast of the developments of the future?

It has been said that much of the advanced literature appearing in the *Transactions* is written by people having graduate degrees and that therefore it is necessary to have graduate instruction before one may be expected to understand the material in such *Transactions*. If this be true, would it not tend to limit the membership to those who have done graduate work? Would it not be a better policy to strengthen the backgrounds in mathematics and science in our undergraduate programs to such an extent that a man through self-study may come to understand the technical literature and thus keep abreast of developments in his field?

It has been observed that the shortage of engineers has been considerably intensified because graduates of earlier years cannot cope with the problems now before us. If this be true, and there appears to be abundant evidence to support the statement, it arises from either of two sources: either the training has greatly obsolesced in value to the individual, or it was not up to the proper level in the first place. While it is always true that one cannot anticipate the nature of professional practice a couple of decades hence, it is in general possible to instruct in the basic principles to the extent that will make it feasible for the individual to keep abreast of such developments through reading. Studies of case histories would indicate that in the main the engineering training in the past has not been of sufficient strength in terms of basic principles to allow the individual to keep abreast of modern developments.

Evolution of American Engineering Education

Perhaps a better understanding of the present situation might be had by reviewing briefly the evolution of engineering education in this country. In 1866 there were about six engineering colleges of established reputation, and only 300 men had been graduated in the previous 31 years. By 1870 the number of engineering colleges had risen to 21 and the number of engineering graduates to 866. By 1896 the number of institutions had increased to 110, and today the number is 192, of which 148 have one or more curricula accredited.

In 1896 an attempt was made by this Society to rate the schools then existing. There were 31 Class A colleges requiring for entrance at least algebra through quadratics, plane geometry, solid geometry, or plane trigonometry. There were 33 Class B colleges requiring algebra through quadratics and plane geometry. There were 25 Class C colleges requiring less than algebra through quadratics and plane geometry. There were 18 Class D colleges not offering complete courses in engineering, but giving analogous work, and there were three Class E colleges having no entrance requirements as such but doing work of an engineering nature. It was in this situation that this Society, organized in 1893, began its work. There is no question but that the leading spirits in engineering education, through this Society, exerted great influence in the raising of standards of the schools during the early part of the present century.

During that first decade of the present century the four-year engineering curriculum was pretty well crystalized. Its major features have remained practically constant in the older curricula for the past forty years.

Wickenden comments that "By 1900 it was generally recognized that American laboratory installations and methods for the teaching of engineering were not surpassed and not often equalled in any other part of the world. As much could not rightfully be claimed, however, for much of the theoretical instruction and especially for instruction in design." An examination of curricula of 1910 and of the present day indicate that not very much has been done respecting either the science content or instruction in design, even though Wickenden's observations were written over twenty years ago.

In this country we have relied heavily upon the laboratory report and problem

methods of teaching. In Germany, for a number of decades, it has been the policy to use the project method during the last two years, focusing largely upon design. The project method encourages resourcefulness, ingenuity, and individual judgment, whereas the problem method encourages belief in one and only one solution, and mitigates against resourcefulness, ingenuity, or individual judgment.

In this country, after the turn of the century, came the great development in most of the engineering schools connected with the land grant colleges and state universities. Curricula were patterned after the prominent schools of the day, although not generally at the same level of operation. By the end of the first world war the major development of engineering schools had occupied a period of only 50 years.

Between the two world wars many engineering schools were preoccupied with the problem of the peripheral areas, such as the relation between engineering and business, sales engineering, and contiguous areas in which only a superficial knowledge of engineering would be necessary in order to carry on the work. There resulted the establishment of a considerable number of programs of less than standard quality so far as the engineering content was concerned, although the programs themselves had significant value. While this was going on there was very little strengthening of either the scientific or the engineering content of the curricula.

It was at the end of this period that World War II burst upon the scene. It was soon made abundantly clear that a great many graduates of engineering schools of even recent date could not then cope with the problems with which this country was faced.

Comparison with European Education

From the foregoing, it may be seen that the development of engineering education in this country has received its stimulation largely from within the teaching profession. In Europe the programs in engineering education have been influenced by the strong part played by the state and the engineering profession. In Germany, under such guidance, the pattern of the *technische hochschule* was being well established at the time that our engineering colleges were just beginning to emerge. Seven of the eleven *hochschulen* were set up between 1870 and 1879—two more were added by 1885, and the last two in the early part of the 20th century. It is worthy of note that the eleven *hochschulen* served a population of 80 million people, while in this country with a population of 160 million we have 192 engineering schools of various levels.

In Switzerland the Federal Polytechnic School at Zurich was organized in 1854 at the university level. It exerted considerable influence upon the development of the schools of Germany and Italy.

We know that, following the war, many German scientists and engineers were taken behind the Iron Curtain. Undoubtedly the Russian schools which are patterned roughly after the German *technische hochschule* have been greatly strengthened by this inflow of German-trained technical men. We learn from our own technical press that up to 1948 Russia was graduating about 30,000 engineers a year and about 70,000 technicians a year. While I am told that the Russian schools are deficient in laboratories such as are employed in engineering schools in this country, the technical content is at least equivalent to that for the master's degree in most American schools.

The great success of the technical schools on the continent of Europe has been made possible by the quality of preparation received by the students entering such schools. In our own country the high school system, which now graduates half of a given age group, has reached proportionately more youths than similar schools in any other country. By the same token the students are not so highly selected and hence cannot receive so strong a preparation as was true in the German *gymnasium*. The effect upon *our* university and technical college system is of course that we must pick the student up

at an earlier point than would be true in the *technische hochschule* in Germany or Switzerland. In planning our programs we should not be guided by the number of years spent by the student in our university or technical college system so much as we should be guided by the quality of the end result of the total program offered the student.

A Program of Action

I have appointed a committee, under the chairmanship of Vice President Grinter, whose prime function will be to aid in the stimulation of a thorough review of our engineering educational procedures judged in the light of the technical needs that may be required in all parts of this country. It is the hope that every campus will have an active, thoughtful and far-seeing committee working on this problem for the purpose of development of a policy respecting the quality of engineering education that can be used on a national scale.

This study should be made not alone with respect to the meeting of the immediate needs of the profession and of the country. Students now being trained in our colleges will be responsible for the professional attainment over the next three decades. This need, as well as the present need, must be serviced by the training we are giving now.

I would urge all who have a part in this study, and in the training of engineers for their future service to their community to see that due provision be made for the development of intellectual and moral growth on a broad base. We must not be caught in the act of preparing for a world of materialism alone. Materialism has its distinct use, but it occupies one part in a full life which must preserve and enhance its cultural and spiritual values.

I do not wish to be interpreted as recommending the adoption of the *technische hochschule* system in this country. We do not have the preparatory training necessary to support such a system. It is clear, however, that some of our schools at least should attain a level of training comparable to that attained by the *technische hochschule*.

Since in the future engineers themselves are not going to be available in numbers sufficient for use as engineering aides, it will be necessary to see to it that such aides will be trained in adequate numbers. It is essential also that the training for engineering aides be well articulated with training at higher level so that good students capable of advancement to higher level training may transfer easily without serious loss of time.

It may possibly be worthwhile for certain schools having the necessary strength of staff to undertake a program of training at a more advanced level than is commonly employed in engineering schools today. If such programs are undertaken, however, they should be articulated with programs at other levels.

In review of the foregoing discussion it seems clear that consideration should be given to a number of important factors, among which we could list the following:

1. The levels at which different types of programs would terminate, and the manner of articulation between programs.
2. The overall length of programs in order to achieve their objectives.
3. The extent to which existing programs should be strengthened by further training in science.
4. The manner in which science training in a given program may best be exploited throughout the remainder of the program.
5. The manner in which creative work, such as design and development, may be enhanced by training techniques during the course of the program.
6. The character of staff necessary to carry out the whole enterprise.

Obviously there are other factors that should properly be included in so large a study, but these will become evident as the study is carried forward.

The Society's Responsibility

America occupies a peculiar position in the world today. As a nation we are obliged to be ready at all times adequately to defend ourselves. More than this, we have made it clear that we will aid others to defend the freedom of men wherever their subjugation is threatened. We look upon these freedoms in the historical sense that they have been hard won over centuries of struggle, and we do not propose to lose them without a fight to the finish. To be effective either by ourselves or in concert with our neighbors we must depend on quality rather than numbers in our engineering and scientific position. We are now substantially on our own with no opportunity to draw upon men from other places for specialized leadership in this country.

This Society, constituted as it is from all phases of engineering education, has the grave responsibility of leadership in technical education, not alone for ourselves but for that whole segment of the world that looks to us for leadership. All parts of the Society share in this responsibility.

Last Call

for

Learning Aids to be Reviewed

by the following divisions of the Society

CIVIL ENGINEERING
ELECTRICAL ENGINEERING
MECHANICAL ENGINEERING
MECHANICS
MATHEMATICS

These are to be published in a catalogue by the ASEE Committee on Teaching Aids in approximately June of 1953. Items for review *must be received* by January 15, 1953.

Will you please help this activity of the Society by doing one or more of the following:

1. Send us models, pictures, drawings, charts, etc. that you have made as learning aids.
2. Send us information of any of the above which have been made by your colleagues.
3. Let us know of industrial learning aids which you have used and liked, wholly or in part.

Any offer of a learning aid to be reviewed should be submitted to the Chairman of the Teaching Aids Committee

Professor Carl W. Muhlenbruch
Northwestern Technological Institute
Evanston, Illinois

The offer will be forwarded to the appropriate reviewing committee.

Military Research in the Universities*

By JAMES R. KILLIAN, JR.

President, Massachusetts Institute of Technology

As the representative speaking on this panel in behalf of the universities, I am under obligation to make my personal opinions and biases perfectly clear. I head an institution which has reluctantly felt it necessary in the public interest during the past twelve years to engage in military research on a substantial scale and which looks forward eagerly to the time when this will no longer be necessary. I reflect this policy and experience of my institution. I am aware of the hazards and difficulties inherent in military research and share the apprehensions about it which have been expressed by numerous educators. I speak out of experience in saying that the conduct of large classified military research projects imposes vexing and heavy burdens on the university.

Except in time of war, the acceptance by universities of large research projects devoted to classified development work (which is the kind of sponsored research discussed in this paper) can be justified only on the basis of national need, by the fact that the university is uniquely qualified to do the work, and by the possibility that the research will advance education. A technological institution has special resources which impose on it a responsibility to undertake military research different from an institution such as a liberal arts college.

In this period of rearmament, the universities and university faculties generally must undertake defense research and other emergency services for the government because these services are needed. They must accept their proper share of responsibility in meeting the security needs of the nation. Thus they are faced with the difficult dual responsibility of assisting the government in its immediate emergency needs while at the same time preserving as fully as possible their basic and long-range activities in education and research, which is their primary responsibility. Normally, all the activities of the university should be tested by their contribution to the advancement of knowledge.

Is it possible to discharge this dual responsibility? Not without some sacrifice of long-term goals in my judgment. Our problem is to minimize this sacrifice.

With this statement of my personal views, let me now turn to some quantitative facts about the over-all situation.

Research is a Huge Business

The conduct of research, together with the allocation of research funds, has become a huge business in our country. Informed estimates of the total expenditures for research in the United States approximate three billion dollars a year, a sum almost as large as the total federal budget twenty-five years ago and now equal to about one per cent of the national product. Who pays for this research? At the present time the government pays for 55 per cent, industry 40 per cent, and the universities 5 per cent. Ten years ago industry paid for 60 per cent, government 35 per cent, and the universities again 5 per cent. The 1952 figures, of course, reflect the great expenditures by the government for defense research. But the sig-

* ASEE Meeting at Dartmouth Panel on "The Impact of Government-Sponsored and Government-Operated Laboratories on University Teaching and Research"—The University Viewpoint, June 24, 1952.

nificant fact that remains is that the government has become the chief agency for initiating and financing research.

We all can join in hoping that this is a temporary condition dictated solely by national security requirements.

The distribution of the research dollar is of course less significant that the distribution of the research man. The best available figures show that at the present time there are some 600,000 scientists and engineers in the United States. Of this total, about 70,000 scientists and 55,000 engineers, or a total of 125,000, carry the research load of the nation. Of this total of 125,000, some 60 per cent are in private industry, 33 per cent in government, and 10 per cent in universities and other non-profit institutions such as hospitals. If these estimates are correct, the principal load of basic research in the United States is being carried by about 12,000 scientists and engineers. The last estimate which I have seen indicates that of this number, about 9000 to 10,000 are in the universities, the remainder being in hospitals and other non-profit institutions. It is this small handful of men on whom the nation is dependent for most of its uncommitted research as well as a great volume of applied reseach. This is the most graphic way I know of for pointing out how important it is that we provide the best possible conditions for this handful of men to carry out their work effectively and that we give them support in the form that will free them for creative activities. It is also the most graphic way available to point up the disproportionately small amount of our total creative scientific manpower effort that is going into basic uncommitted research.

Twenty years ago, 15 per cent of the nation's total research expenditures came from funds possessed by the universities. To a considerable extent these were funds that permitted free and uninhibited use. Today the universities on their own have funds which are equivalent to only 5 per cent of the total national research expenditure. Is it not proper to conclude that they have lost freedom of action in proportion to this decrease in the percentage of total expenditure, even though they have greatly increased funds available to them for research.

This is a function of funds, of emphasis, of environment, and of men. The funds hardest to come by in my experience are relatively small funds to exploit some new idea that does not yet justify support in the form of a specific grant by an outside agency. By contrast, it is relatively easy to obtain funds for research projects well under way. We need venture capital in education no less than in our economy.

Need for Fundamental Research

No group appreciates more clearly than this one the need for a strong program in fundamental research; of that I am sure. But I am also sure that we have been more successful in talking about the importance of fundamental research than we have in doing something about it, and I need only to point to the reluctance of Congress up until this point to make adequate funds available to the National Science Foundation. This failure to support the Foundation with funds has been a loss to basic science and the long-term welfare of the nation. Funds are far more readily available for applied programmatic research than they are for uncommitted research. Every research institution that I know feels its hands tied because most of its research funds are restrictively earmarked for specific use. We have no mobile reserve troops to rush in to exploit a breakthrough; no funds free for reconnaissance of new terrain. This may seem strange in the face of the fact that total research expenditures in this country have increased ten times in the last twenty years, but it is true nevertheless.

The situation is much better than it otherwise would be because of the well-conceived basic research policies of the government agencies which contract for research in the universities. The Office of Naval Research has done a superb job in stimulating and supporting basic research. In the Department of Defense, the Research & Development Board has steadily

supported the concept of basic research in those areas where the advance of knowledge is important to the military effort. The Department has only recently reaffirmed this policy, which provides for the support of basic research performed as an integral part of programmed research committed to specific military aims and for the support of academic research that promises ultimate military application. The limiting factor here, of course, is the test which must be applied that the research promises ultimate military application. The National Institute of Health, the Atomic Energy Commission, and other government agencies have been similarly concerned with the support of basic research.

The magnitude of the defense research program at the present time is of course the largest part of our total national research effort, both in terms of dollars and men. It is here that the shortage of manpower begins to pinch. There is no question but that the manpower resources are thinly spread. This is especially true in terms of the handful of people who have the imagination and creative powers to provide the leadership required for steady progress. Perhaps our most critical present problem is how to utilize more efficiently this small number of available leaders.

Training of New Leaders

Related to this problem is the training of new leaders. With the present manpower spread as thinly as it is in our universities, are we maintaining the quality of advanced education that is so essential and are we providing the environment in which the truly creative mind has the best opportunity to develop and to do creative work?

Again the answer must be qualified and not a clear yes. Some gifted teachers have shifted from teaching to military research. The interest of others has been divided or diverted. As a result there has been an undeniable loss in total teaching and research effectiveness. There is also some evidence that we have not been educating in this postwar period as many highly creative minds as we might have expected. Offsetting this is the fact that government research has increased our capacity to train advanced students and has frequently improved the quality of our education. In the engineering field, especially, government-sponsored research provides enlarged thesis projects which have given a new dimension to graduate training. The larger-scale projects afforded by sponsored research enable young engineers and scientists to acquire research techniques which can be learned only by participation in organized team research. Some of the sponsored research laboratories in universities have been superb training grounds for research engineers by providing them with the experience which has accelerated their creative contributions to industry.

Any casting up of debits and credits must lead to the conclusion that in the long term, a heavy burden of classified development research will be a handicap to our universities and in the long run a handicap to the security of the nation. I must agree with Whitehead when he defined the task of the university "as the creation of the future." This is especially true of our schools of science and engineering. But they also must help protect the future by aiding our defense in the current emergency.

All of us share the hope that the military responsibilities of our universities can be reduced as rapidly as consistent with national security and that we can concentrate on our main objective—the unhampered advancement of knowledge. We hope for a condition where the best minds in science and engineering in the universities will feel it proper and of first importance to give primary attention to long-range goals.

One of the best ways for the employment of our university personnel for military purposes is the Hartwell type of project, or study group. Under this arrangement, a group of highly qualified men come together for a brief period of time and examine a problem in a fresh

and uninhibited way. Several projects of this kind have been enormously productive, having made major contributions to military thinking and planning. A major advantage of this type of use of scientific manpower is that it does not uproot the men nor divert them from their normal educational and research activities except for a brief period of time.

This study-project technique also aids in informing an increasing number of qualified scientists and engineers about military problems and thus builds up an informed pool of men ready to help in a more critical emergency.

There are a number of large research projects with military objectives managed by the universities. These projects are vitally important and must be seen through. It is important, however, so to manage these projects that they do not improperly or seriously disrupt the educational programs of other institutions through unreasonable competition for manpower, particularly through excessively high salary incentives. These large projects are being managed carefully to avoid this effect, and it is now clear that they can be handled without seriously weakening the over-all educational resources of the country. It must be said, however, that these projects cannot get as many top-flight men as they need for maximum effectiveness. We must accept this shortage as a necessary balancing of forces if we are to continue an adequate amount of fundamental educational and research activity while serving the government's military needs.

Financial Aspects

Let me now turn to some financial aspects of sponsored research. For many years the research activities of our nonprofit institutions have been largely supported by grants in aid, which pay only a part of the total cost of the research. The institution has been expected to take care of all indirect costs together with the salary of the principal investigator. Now this system would have been fine if the resources of our institutions increased in proportion to the increase in the volume of research, but this has almost never happened. We have witnessed a great increase in the total volume of grant-in-aid research while the effects of inflation were actually reducing the institution's own income. Frequently we in the institutions have not recognized the impact on our economies of these opposite trends and we have steadily incurred added indirect expenses while happily watching the total volume of grants-in-aid increase. The reckoning has been inevitable and many institutions are now beginning to realize that they can pile up grants-in-aid until they bankrupt themselves.

This is not a problem primarily for the agencies making grants-in-aid. It is a problem primarily for the institutions receiving these grants. We should not delude ourselves that grants-in-aid do not cost anything. We should also realistically budget funds for our part of the cost of the grant-in-aid so that we know what our own contributions are toward the costs of the project. We in the research and educational institutions need a better cost accounting of our indirect research costs. My own experience with the budget of an educational institution indicates that the overhead cost of this kind of institution approximates 50 per cent of the salaries and wages of the personnel working on research. Some institutions run higher than this, others somewhat less, depending in part upon the volume of research which is done.

It is my personal conviction that the federal government must face the problem squarely now that it is financing about 55 per cent of all the research in the country and is spending many millions of dollars on research at non-profit institutions. This vast research expenditure could do serious damage to the economies of these institutions if it were handled purely on a grant-in-aid basis without contributing to indirect costs. It is my conviction that the government should accept a trustee responsibility not to so handle its research funds that in the long run it will weaken the institutions utilizing these funds. A

related matter which is an ever-present concern of the colleges is the extent to which we are coming to depend upon current funds. Since 1940, the operating expenses per student in those institutions on which I have figures have risen about 80 per cent. This additional cost has been to a large extent covered by current or "soft" income. This is a perilous situation and one directly related to the support of research by the federal government. It points up again the importance of sound fiscal policies in our institutions as well as the importance for the government to plan its research programs in the universities to insure maximum stability and continuity.

Our policies in dealing with these fiscal matters, let me add, must be formulated in the interest of educational and research objectives and not narrowly for financial considerations.

Restrictions

Another acute problem posed by government research in educational institutions is the imposition of restrictions, paper work, accounting, and other impedimenta which are foreign to the methods of operation of the universities. One of the reasons why our educational institutions can be effective in basic research is that they have created an environment benign to this kind of activity. The effectiveness of this environment in part results from the absence of restrictive procedures that are perfectly appropriate for other types of organizations, as for example, procurement procedures for accounting, property accountability and purchasing. When the government requires these procedures, it tends to reduce the effectiveness of the institution receiving the grant and to change its character. This is a complex problem that is occupying the attention of many people both within and without government, but I think it important to reiterate it if for no other reason than the improper application of policies and restrictions on our universities will reduce their usefulness and their effectiveness in handling the government research which is needed.

Under present conditions it is not possible to avoid all research requiring security restrictions, but we must admit that such restrictions do damage to the ideals and programs of our universities. The imposition of restrictions on publication of research results, either for secrecy or patent reasons, can become incompatible with the basic concept of an educational institution as a source and distributor of knowledge. Any arrangement which inhibits free and effective work in any scholarly field involves a penalty. To minimize the effects of classified research, the university should seek to segregate it as much as possible so that it does not limit freedom of communication within the normal program.

Summary

It is perfectly clear to you that my remarks have been largely of a clinical nature. I would summarize by saying that it is largely up to our educational institutions to face up to the problems of sponsored research with wisdom, with independence, and with strict adherence to their educational ideals. It is not proper, in my mind, for an educational institution deliberately to seek a military research project with selfish or financial motives in mind. It is only proper for it to do so when its services are needed by the nation.

If we were to review the history of the world's great universities, we would find, I venture to suggest, that their periods of greatest achievement were periods when they most effectively responded to the pressing needs of their times. For the universities to seek each individually best to serve our period in our own way is the only general guiding principle which we can apply in accepting or rejecting or conducting military research.

The Atomic Energy Commission Looks at the Future*

By T. KEITH GLENNAN

Commissioner, U. S. Atomic Energy Commission
President-on-leave, Case Institute of Technology

The Atomic Energy Commission and its staff are keenly aware that if atomic energy is ever to be made importantly useful in peacetime applications, we must depend to a large measure in the coming years on a tri-partite team. Industry, educational institutions, and government must each take an effective part in this development. This team must be strong as individuals and particularly strong as a team if we are to be successful.

Industry must do its part by participating in atomic energy developments even though significant short-term financial return on investments may not easily be foreseen. This business, if one can call it by that name, is still so young that the opportunities to develop new processes or products are not readily apparent. Nevertheless, the atom is too fundamental to be ignored and our knowledge in this field is increasing at a rapid rate. Industry is beginning to awaken to this situation and to inquire as to the manner in which participation can be achieved. The Commission welcomes and is encouraging this attitude believing that production interests will best be served in the long run by the competition engendered by the participation of production people.

Our universities, and particularly the science and engineering schools, must take on even greater responsibilities in research and in training the new generations of scientists and engineers. These institutions must turn out the required number of professional personnel, well-trained in the fundamentals of science and engineering and equipped to fit into the programs of industry and government. Here, too, there are increasing and encouraging signs of interest on the part of the educational world. The Commission has long maintained a policy of leaving educational matters to educators and it is gratifying to see the manner in which the educational fraternity is accepting its responsibility in this new field.

Today the government is in the dominant position by reason of an act of Congress and because there is no effectual international control of atomic energy. It must be the continued responsibility of national governments to maintain complete control of fissionable materials, each within its sphere of influence. Our government must, whenever consistent with the assurance of the common defense and security, act so as to strengthen free competition in common enterprise, improve the public welfare and promote world peace. Changing conditions as we go forward will alter the relative importance of each of the members of this team but these changes in importance will occur only if the industrial and educational partners are well-informed and interested.

Present Situation

Let's look for a moment at the present state of the art and then address ourselves

* Annual Meeting of ASEE, Dartmouth College, Hanover, N. H., Tuesday, June 24, 1952.

more particularly to the developing needs of this field which will be of interest to the engineering-educational fraternity. We know how to produce fissionable materials and to produce them in substantial quantity. While great advances have been made in the technology involved in the separation of U–235 atoms from U–238 atoms and the transmutation of U–238 into the end product plutonium, it must be remembered that throughout the past nine years almost all of the work in this field has been to meet military and defense requirements. Such an atmosphere is not particularly conducive to relaxed thinking and the taking of extraordinary chances in the search for radical improvements. Nevertheless, it can be said that fissionable material is in reasonably abundant supply and that our supplies are becoming increasingly large at an accelerating rate.

We know how to manufacture destructive bombs of many types on mass production schedules. We have substantial stockpiles of atomic bombs. We are expanding our plants for the production of fissionable materials and enlarging our manufacturing activities to enable us to make even more weapons. Our development centers are busily engaged in finding ways of better utilization of these still precious fissionable materials.

We are building mobile reactors for naval use. If we are successful—and there are now only a few skeptics left—there will be a firm demand for conversion to naval propulsion under atomic power. We are in the early stages of the designing of a reactor for the propulsion of aircraft. Although this is a job of almost unbelievable difficulty, there is little question in my mind that, given an adequate amount of money and sufficient time, success will be achieved.

We have generated small amounts of uneconomical electric power incidental to the main experimental purpose of a reactor. What the future holds for this production of electric energy from atomic energy only time itself will tell. If reactor developments turn out successfully and costs can be reduced—and I am certain that we will be successful in these matters—there will be an increasing demand for stationary nuclear power plants. This demand naturally will arise first where present costs for electrical energy are high and this suggests that such a program may have an important place in any future Point Four programs. As you probably know, the Commission has made agreements with four industrial groups permitting them to make surveys and studies leading toward the finding of ways by which a larger share of the task of developing, building and operating reactors can be carried by industry. One of these groups, the Dow-Detroit Edison combine, has already agreed to participate in the financing of continued research and development studies. The other groups are not far behind and I assure you that their interest is very real. It is, of course, too early to foresee the results of these industrial studies but I am certain in my own mind that industrial participation and the results of competition in accordance with our normal industrial pattern will hasten the day when the generation of power through the use of nuclear fuels will become an economic reality.

A large and continually growing interest in the use of isotopes for research in medicine, agriculture and industry leads us into another facet of the atomic energy business. You may give your imagination free play in this matter for the importance of the isotope as a research tool cannot be over-stated. I am sure that many of you here could wax much more eloquent than I about the doors which may be unlocked in the future through the use of radioisotopes.

Each of these activities will call for an increasing number of scientists and engineers as the years go on. The actual numbers required will depend upon the degree of success that may be achieved in the developing of the programs. We are just now in a position where we can see occasional glimpses of the atomic energy field ahead of us. We cannot with certainty predict the exact nature of the developments to be undertaken in the next

five to ten years. We do know one thing with certainty—none of the hoped for progress will occur unless the minds of well-trained men are available and interested in this field.

Future Needs for Manpower

So much for the generalities of the present state of the art from which we can take only a dimly lit view into the future needs for manpower in the atomic energy program. The members of this panel have been asked to address themselves to a discussion of the impact of government sponsored and government operated laboratories on university teaching and research. Having become over the years a Jack of all trades and an expert in none, I thought that your interests would be best served in this matter if I asked for the advice and counsel of the directors of our important laboratories. I asked them several questions and propose now to report to you a composite of the answers which were given to me.

My first question was—What is the present need within the atomic program for college graduates in the sciences and in engineering? How many Ph.D.'s are needed annually? How many men with Master's degrees or Bachelor's degrees only?

The Oak Ridge National Laboratory has estimated that they will hire 170 new technical men between July 1, 1952 and June 30, 1953. Thirty of these will be Ph.D.'s, 45 men who hold Master's degrees, and 95 who hold Bachelor's degrees. Half will be in the engineering-sciences.

Brookhaven National Laboratory is just beginning to stabilize in its operations. The large equipment—the reactor, the cosmotron, the cyclotron—are now in use or very nearly ready for use. Brookhaven has a young staff which probably means that their turn-over rates for the next few years will be low. They have been employing 50 to 60 men each year, 30 to 40 of these being Ph.D.'s and 20 men holding the Master's or Bachelor's degree. It is probable that the next year will see a decrease in the number of new hires at Brookhaven National Laboratory. As a guess—25 to 30 qualified scientists and engineers each year may be the going rate of employment at Brookhaven.

Los Alamos—It may be interesting for you to have a picture of the distribution of our present staff at Los Alamos. There are 482 men holding degrees in science—257 holding the Ph.D. degree, 96 a Master's degree, and 129 the Bachelor's degree. There are 192 engineers employed at Los Alamos. Of this number nine hold the Ph.D., 25 have Master's degrees, and 158 Bachelor's degrees. The next 12 months will require a minimum of 170 new scientists and engineers and it is estimated by the Laboratory that the following pattern will obtain: 120 people will be required in the sciences—64 should hold doctorates, 24 Master's degrees, and 32 Bachelor's degrees. About fifty will be required in engineering, two with a Ph.D., 6 with a Master's degree, and 42 with Bachelor's degrees. Their principal interests are in the mechanical, electrical and chemical engineering fields. I would add an editorial note of caution here. I think that it is probable that this number may be substantially increased in the near future. It is highly probable that replacements alone will require a minimum of 75 to 100 persons annually—⅓ of these being engineers.

Argonne National Laboratory. The staff of the Argonne National Laboratory is fairly well stabilized by now. Last year they hired 26 Ph.D.'s, 17 Master's and 26 Bachelor's for a total of 69. During that same year 61 persons terminated, 7 of whom went to other AEC installations and 7 returned to universities for further graduate work.

Going beyond the laboratories, and anticipating a very substantial expansion in our program, money for which has been asked of the Congress, one can estimate that the Atomic Energy program will require, in addition to replacements for people currently employed by the Commission some 4500 scientists and engineers over the next four years.

Cooperation Between AEC and Universities

The other questions asked of the laboratory directors related to the manner in which cooperation was being achieved between the AEC and the colleges and universities. While I am sure that all of you are familiar in some degree with these relationships, I though it might be well to review them again for you. From this recounting it will be evident that the laboratories are having an influence on the teaching and research programs in engineering education. I would guess that this relationship will become more important as time goes on and particularly so as educational institutions themselves begin to pick up a larger portion of the responsibility for training and research in the atomic energy field.

In all of our laboratories graduate instruction is carried on in cooperation with neighboring colleges and universities. Graduate thesis programs have been set up, summer graduate student programs are in operation, summer staff appointments are quite generally available for academic personnel—these situations give an appearance of a healthy, cooperative pattern.

The Oak Ridge Institute of Nuclear Studies, sponsored by 30 universities in the South and Southwest, provides an excellent example of mutual assistance in this field. This regional group was formed to stimulate the development of research programs, to foster and encourage the widespread dissemination of knowledge concerning science and technology, and to provide a bridge between sponsoring institutions and the Commission in the improvement of methods of education and training in the nuclear field.

Assistance is provided to university scientists in making arrangements to participate in the research and development programs at Oak Ridge. Graduate students employed in the laboratory are encouraged to continue work toward professional degrees through the Institute and assistance is given to graduate students from the sponsoring universities in arranging for thesis work to be conducted at the laboratory on both classified and unclassified problems.

It is clear, both from our observations and from testimony of university people, that the Oak Ridge Institute of Nuclear Studies has been highly successful in establishing and maintaining a fine degree of cooperation between the laboratory at Oak Ridge and the university community.

Similar groups have been organized about our other installations. Associated Universities, Inc., composed of nine eastern universities, actually operates the Brookhaven National Laboratory. We are most happy about the increasing effectiveness of relationships between the laboratory and the faculty members and graduate students of educational institutions in the East.

At Argonne National Laboratory we find that approximately ten per cent of the scientific positions in the laboratory are for visiting professors and graduate students working on problems of mutual interest to the laboratories and the universities. At Hanford and at Los Alamos cooperative programs have grown up and are contributing to the health and scientific improvement both of the Commission's installation and of the universities involved.

The Commission has long recognized that science cannot depend upon our present state of knowledge if we are to maintain a rate of advance in the atomic energy field. Accordingly, we are calling on university scientists and engineers to carry out specific research and development projects which have a bearing on our program. As a measure of this activity—we now have in effect about four-hundred contracts with various academic institutions. In general these projects are conducted on an unclassified basis.

The Commission is grateful to the universities and engineering schools for their cooperation in all of these endeavors. We are particularly appreciative when we realize that financial problems of unprecedented severity face most of the institutions involved. We are watching with

interest the development of specific courses and, in some cases, of entire curricula, covering work in the nuclear field. As in all matters in education, it is wise to proceed slowly rather than rushing into a field of specialization such as reactor engineering. It will be the policy of the Commission to continue to supplement the activities of the educational institutions of the country and to provide specialized training only to the extent that the Commission's program requires such activities. Thus we expect to conduct special training courses such as that given by the Oak Ridge School of Reactor Technology for some time to come. We look upon such courses, however, as emergency programs and we hope eventually to abandon them completely or to change them into specialized classified on-the-job training programs.

Fellowship Program

The Commission's fellowship program with which you are all familiar will gradually be taken over by the National Science Foundation. This program, initiated in 1948, has provided support for some 1025 individuals in either the pre-doctoral or post-doctoral programs of the Commission. It is too early to predict the impact of this particular activity on our national atomic energy efforts. It is clear, however, that each of the individuals involved will be making direct and indirect contributions to the Commission's program.

You may ask me what universities and colleges can do to assist further. My reply would be to continue your traditional science and engineering curricula—and even turn out a increasing number of well-trained, well balanced scientists and engineers—strengthen yourselves by the elimination of frivolity and a dependence on Washington for financial support. Prepare yourselves thoughtfully to take these new ideas to the campuses and above all be cheerful and enthusiastically aggressive.

Sections and Branches

The **Michigan Section** met in the Engineering Society of Detroit building under the auspices of the University of Detroit on Saturday, May 10, 1952. W. P. Godfrey, Section Chairman, presided at the 2:00 o'clock session. Members and guests were greeted by The Very Reverend Celestin J. Steiner, S. J., President of the University of Detroit. S. C. Hollister, President, ASEE spoke on the topic "Adequacy and Standards of Engineering Education." Following this paper, L. E. Grinter, Vice-President ASEE spoke to the group on "The Improvement of Teaching."

At a brief business session in the evening, the following men were nominated and elected to serve as officers of the Michigan Section for the 1952–1953 year: Chairman—C. C. Winn, Vice-Chairman—F. L. Schwartz, Secy.-Treas.—C. C. Sigerfoos. W. P. Godfrey, was appointed to represent the Michigan Section on the General Council of the National ASEE.

"Educating Engineers for 2000 A.D."*

By C. C. FURNAS

Director, Cornell Aeronautical Laboratory, Inc., Buffalo, N. Y.

It may be appropriate to begin this discussion by calling up a voice of the Fourteenth Century, "The lyfe so short, the craft so long to learne." [1] Certainly since Chaucer wrote these words some six hundred years ago the situation has not eased. Though the span of human life has lengthened very substantially and very beneficially, the task of learning the craft has grown many times greater, particularly in the field of engineering. The operation of exploring, investigating and criticizing the process of educating for engineering and carrying on with the profession itself is certainly going to be a standing order for a long time.

May I also observe that the task of educating engineers for 2000 A.D. is not a chore for the next generation alone, but is an operation which faces us now because those who are presently graduating from various educational institutions will, in some cases, be active in the profession of engineering when the twenty-first century begins.

One would be very foolish, indeed, if he approached this subject with any great feeling of confidence. Rather he should approach it with a large amount of trepidation—which I do. I assume only one thing, namely—that a large number of people concur that there are and will for some time be a number of unsolved problems in engineering education, and that the number of different proposed solutions will just about equal the number of persons who are willing to offer them. Since my deliberations will have no more merit than dozens of others that you probably have heard, or will hear in the future, or that you can devise yourself, my contribution is merely that of another person's thinking—for whatever it may be worth.

What Is an Engineer?

In attempting to solve a problem, it is usually considered good form first to analyze the situation (the old formula for rabbit soup: First you catch your hare). My analysis shall consist largely of a series of observations on the characteristics and functions of the people who make up the engineering profession.

When one seeks the answer to the question, "What is an engineer?" he gets a surprising variety of answers. The ideas of the function of the fraternity are far from unanimous among its own members. At one end of the spectrum of opinion there is the thought that the true engineer is a research man of some specialized learning and an unusual set of talents—C. F. Kettering might be taken as an example. At the other end is the person who considers that the engineer is essentially a scientific business man—Herbert Hoover, for instance. It is obvious from the responses that engineers are of all sorts, kinds, and sizes. Even less agreement is found among engineers themselves and among the educators as to how the individuals who are to make up this polyglot product should be treated in the educational mill. Obviously, it would be desirable to find a universal formula that would enable everyone to receive exactly the optimum treatment to prepare him for the role which he is eventually going to as-

* Address at Annual Meeting of ASEE, Dartmouth College, June 26, 1952.

[1] Chaucer—"The Assembly of Fowles," line 1.

sume in our industrial society. That is a fond hope which will never be realized but perhaps we can improve our present performance.

With this discouraging beginning of wide differences of opinion one ceases asking opinions and begins to look at the record to find out just who is included in this profession of engineering; what do they do, and what are the characteristics which seem to make them successful? Even the blind man, by making enough tactile observations, can determine the shape and character of the elephant.

First, as to numbers. The number of engineers is, of course, partially a matter of definition, but the professional engineering societies of the country have reasonably exact criteria and those who are included by the rough definition of the profession number about 400,000 in the United States at the present time. They are, then, somewhat less than 3/10 of one per cent of the population and, hence, a relatively select group—at least as far as the census taker is concerned. One's first conclusion then is that if engineering calls for specialized education, it cannot be of a universal character because you cannot shape a major share of the national educational system around only 3/10 of one per cent of the members of society—no matter how important they may be.

Delving into the data a bit further, one finds that hardly more than 15 per cent of the engineers are, at the present time, in the field of research and development. This, then, indicates that the brand of critic who feels that engineering education should be devoted only to the preparation for research and development is about 85 per cent wide of the mark, at least as far as the number of people that are involved. I am not in a position to give any exact substantiation of the fact that only 15 per cent of the engineers are in research and development, but there are a few data from the Human Resources Division of the Research and Development Board for the year 1952. Admittedly, they are estimates but probably not far from the truth. At the present time there are approximately 625,000 scientists and engineers in professional activity in this country. Of these, 9 per cent are employed in universities, 24 per cent in government, 67 per cent in industry. Of these 625,000 scientists and engineers about 135,000 are considered to be in research and development. Here again, of course, the listed occupation depends considerably upon definition. Twenty per cent of these are engaged in universities, 23 per cent in government, and 57 per cent in industry. Since a substantially larger per cent of those who are classed as scientists than those who are classed as engineers, are in research, it appears to be quite a reasonable estimate that not more than 15 per cent of the engineers are engaged in research and development. I would be willing to concede, if anyone wishes to argue the point strongly, that this may be by far the most important 15 per cent, but at the moment I am considering only numbers.

Solidity of the Profession

The data, such as they are, also indicate that the engineers constitute a fairly solid fraternity, as far as the educational link is concerned. Most of those who are educated as engineers stay with the calling. Depending upon the estimator and also upon definition, it appears that somewhere between three-fourths and seven-eighths of all of those who have received an engineering education remain in the profession, if you include administrative and executive posts which are closely linked to technical organizations. There is a small and decreasing number who have never received engineering educations who enter the bona fide professional ranks, but new arrivals in these groups are now almost to the point of being negligible. There are a few data, rough as they may be, on the losses to the profession of engineering.[2] Losses by death and retirement amount to about 2 per cent of the number in the profession per year. It is also estimated that

[2] "Employment Outlook for Engineers," Bureau of Labor Statistics Bulletin No. 968, May 1949, page 44.

transfers to other occupations than engineering amount to about ½ per cent of those in the field each year, plus about 5 per cent of the new graduates each year. Thus, the losses by death, retirement and voluntary action are estimated to be about 3 per cent per year. It appears that educating a young man to be an engineer is a fairly serious business because he is probably going to pursue that path until the bitter end.

Another characteristic of the profession is its increasing importance in our industrial economy.[3] In the year 1890 there was one engineer for 290 industrial employees. In the year 1948 there was one engineer for 75 industrial employees. As our civilization becomes more industrialized, it becomes more complicated and relies more upon the services of engineers. Hence turning out the best possible engineering graduates becomes a matter of increasing national concern.

Characteristics Associated with Success

Turning away from the statistics, we can make some observations on the characteristics of individuals who make up the more successful stratum of the profession. In this case one is fortunate to be able to turn to the words of Henri Le Chatelier, one of the prominent scientists and engineers of France.[4] M. Le Chatelier analyzed and compiled the outstanding personal characteristics of the most successful scientists and engineers that he knew in western civilization and came up with the conclusion that four qualities were always present and hence must be basic characteristics of a successful engineer. These were, in order of importance:

1—Activity (or drive)
2—Imagination
3—Judgment
4—Knowledge.

In order to make a check on this judgment of an engineer I turned far afield and investigated an article by a man who made a career of interviewing and reporting on successful business executives in many fields.[5] The author of this article listed eighteen qualities that he had observed in successful executives over the years. The first two were "They work hard," second, "They have imagination" which obviously are in exact correspondence with Le Chatelier's first two prime qualities. The quality which would correspond to Le Chatelier's "Knowledge" in this executive list came as number sixteen in "they are educated." Thus we see that there is a very fine correlation between the most important properties required for success in the opinion of two observers from widely divergent fields.

If I might venture to put in my own two cents worth at this point, I would suggest that there is a fifth quality beyond the four given by Le Chatelier; one which is highly necessary for the bulk of the engineers, namely—adeptness in human relations (that much maligned, much misused term). I am sure Le Chatelier recognized this, and why he did not list it as one of the prime qualities I do not know.

It appears that these five essential qualities—drive, imagination, judgment, adeptness in human relations, and knowledge—fall into three rough groups:

1—Those that can be taught
2—Those that can be encouraged but not taught
3—Those that can be partially taught and partially encouraged.

The first group—that which can be taught—contains but one item: knowledge. That is the area on which the educational institutions, and particularly engineering colleges, have traditionally focussed their major efforts. From the observation of the characteristics of successful men it would seem, offhand, that this is the item

[3] Bureau of Labor Statistics Bulletin No. 968, May 1949.

[4] "The Creation of an Intellectual Elite in Science and Industry," H. Le Chatelier, Société Industrielle de Mulhouse, pages 214 to 235, volume 94, 1928.

[5] "What Makes Executives Tick," by Roy Rutherford, the *Rotarian* Magazine, January 1948.

of lesser importance of the five. May I add in self-defense, however, that I certainly do not believe that one can successfully work from the background of ignorance—cannot operate from a mental vacuum—and there is probably nothing quite as dangerous in any profession as the dilettante—the person who has little knowledge and doesn't know what to do with the little that he does have. Knowledge, though insufficient, is absolutely and basically necessary.

At the risk of diverting the stream of my argument, I should like to make some brief observations on this process of acquiring knowledge. In the field of science and its application, knowledge can be broken up into those homely subdivisions: "Know how," "Know what," "Know why."

"Know how" is the realm of emphasis of the tradeschool or the technical institute. "Know what" seems to represent the center of gravity of activity of most engineering colleges. "Know why" is centered in the field of responsibility of the traditional, pure science curriculum. In my opinion, engineering colleges, as a class have been guilty of having an excessive degree of emphasis on the "know how" and the "know what" and not enough on the "know why." This shortcoming has particularly serious effects for those engineers who end up in the research and development field. There has, however, within the last generation been so much pounding of the drum and beating of the chest about the essential ignorance of our engineers and the fact that they acquire too little of the "know why," that I think there is no point in my dwelling on the matter any further. I observe that there is a gradually increasing emphasis on inculcating scientific understanding into engineering student crania. I think that this is a very hopeful trend and I believe that it will continue.

The second class of items encompasses those which cannot be taught at all—only encouraged, by example and otherwise. In this group I would put the two essential qualities of drive and imagination. The third class of qualities contains those that can be partially taught and partially acquired through encouragement. In this I would put judgment, and adeptness in human relations.

From this line of reasoning I conclude that the bulk of the factors that are necessary for success, cannot actually be taught—they can only be encouraged, and allowed to grow. But nothing grows without a driving force of some sort, so this brings us to the discussion of motivation. In other words: what is it that makes people tick, that an educational system can utilize to improve results?

Motivation

John Mills, long of the Bell Telephone Laboratories Public Relation Department, classified people, at least those that came within his ken, by a very simple scheme. He assumed, or rather observed, that there were four major areas of human interest, or motivation. As an aside I should add that these areas of motivation to be discussed are over and above the three simple biological urges of the human animal—food, shelter, and sex. Perhaps we are discussing the higher levels of motivation. These four fundamental urges, according to Mills, are: "Things, Ideas, People, and Money. The arrangment of these drives in order of their prominence indicates the basic character of the man and, hence, in matters of personnel placement, give a good indication of what he ought to do. For instance, the best type of a person for an engineer might be one who is motivated in the following order: Things, Ideas, People, Money. For the true research man the optimum motivation order might be: Ideas, Things, Money and People. One might observe that since there are four properties and that order seems to be important—there are factorial four ($4 \times 3 \times 2 = 1$) or 24 basic types of people with, of course, gradations between each. I would conclude from Mr. Mills' observation that the educational job to a large degree is to set up environmental practices, human relations, etc., in order to afford optimum opportunity for these various motivating factors to grow and develop in

keeping with the propensities of the individual.

Since I am one who tends not automatically to accept someone else's analysis, I indulged in a bit of cerebral experimentation myself and attempted to set down in order of importance those things which apparently induce or motivate people in the United States to undertake higher education. Selecting my own qualitative observations, I came to the conclusion that the four things that induce Americans to go to college, in order of importance are:

1—Economic reasons (including the woman looking for a man)
2—Snobbishness (including the woman looking for a man)
3—The professional urge (the feeling for accomplishment, per se)
4—Intellectual curiosity.

I regret this order of motivating factors and would like to see it reversed. However, I do not see how I, or anyone else, can do anything about it.

This list which I have just synthesized is, by title, somewhat different from Mr. Mills but is not necessarily in conflict. For instance, the factor that I call "economic" probably corresponds quite closely with that which Mr. Mills' called "money." The one which I class "intellectual curiosity" probably conforms to Mr. Mills' category of "ideas." Between us it would appear that Mr. Mills and I come up with six basic urges or motivation factors which furnish the drive for people in the professional world. Since arrangement of such factors is important in determining different types of people, then we could come up with the conclusion that there are factorial 6 (which is equal to 720) basic types of persons. It will be noticed that $\frac{1}{720}$ is about 0.15 per cent, which is equal to half the proportion of the engineers of the country. So if one assumes that half the engineers are really good, and that the engineer should ideally be one out of 720 types, it would appear that we have a reasonable balance between the motivating factors and the results of our engineering education. This observation, I admit, is pure mental diversion and is not to be taken seriously.

Intellectual Honesty

Perhaps it would seem to be enough of an assignment to consider the intricacies of the elements of success of the engineer as a professional individual, but another facet can readily be viewed in this general discussion—the sociological characteristics of engineers, en masse. During recent decades it has become an increasing popular pastime to chide the engineers and scientists on their lack of social consciousness and conscience—"Why don't you, since you are so smart, do something about controlling the effects of these inhuman Frankenstein monsters you have so cleverly devised?"

There are some who have taken these admonitions seriously, with occasional success, but for the most part the engineers' direct attempts to sweeten and benefit the sociological pattern have been signally unsuccessful—particularly in the realm of politics. These failures are usually attributed to the supposed condition that the engineer is an unemotional cuss, a cold fish, who doesn't understand people. The accusation cannot be accepted in toto. The emotional structure and vigor of an engineer are not particularly different from anyone else's. There are probably few real class distinctions in this field. That he often doesn't "understand" people is probably true. And "people" seldom understand engineers, for the reason that the two groups unwittingly operate from quite different frames of reference. The reason is simple—because of training, background and profession, engineers and scientists, as a class, have a rather high degree of intellectual honesty, and when you get down to cases, relatively few people appreciate, desire or understand intellectual honesty. It is not a popular virtue. It is often far from beautiful and it can have distressing impacts on the emotional reactions.

With great haste, I will add that I am not accusing most of the people in the

world of being "dishonest" in the usual connotation. The average person, in whatever occupation, is scrupulously honest, according to his code. I'm merely saying that many of the codes that human beings have evolved in the process of learning to live together tend to ignore the laws of physics, chemistry, biology and sociology; are loaded with rationalizations; are judged by "What would I like to believe?" rather than "What is really true?"

An engineer knows that a bridge designed by mere wishful thinking will fall down, the chemist knows that he cannot promote a reaction by the emotional waving of banners. Although transfer of training is never complete the engineer, more often than most, adapts this type of logical thought pattern to his dealings with people and then is chagrined and crushed when the mass response is somewhat less than cordial. He assumes, correctly, that the sociological pattern would be greatly improved if there were a strong and permanent inoculation of the beneficent virus of intellectual honesty, but the public will have none of it. We have a civilization of complex gadgets and systems of 2000 A.D. operating in a mass emotional framework which is about the same as it was in 2000 B.C. and the two do not match. Perhaps we're approaching the point of outsmarting ourselves.

The task of improving the basic sociological structure is a serious one and no one has found the solution. Perhaps, however, if the engineer could become a little more adept in his public dealings, and if he could also, in his educational and professional activities, induce a bit of understanding of and appreciation for intellectual honesty in the pliable mind of the general public he might eventually have a substantial effect. This potential sociological role should certainly not be neglected in the pattern of education and training of engineers.

Conclusions

Having now gone through my introduction, by making a quick survey of the field, I will leave out the main body of my talk and jump directly to my conclusions, which I may temper with recommendations. This is unorthodox and perhaps unsportsmanlike, but I have two reasons. First, to go into the discussion of how I go from observations to conclusions would be much too long and probably infinitely boring. Second, I probably couldn't completely defend the steps of my logic anyway. So, if you will bear with me, I would like to throw out my bait just to see how you will react. That is the way you catch fish, and fishing, I might add, is about the highest form of experimentation in the indefinite world; so in dealing with an indefinite subject, this may be the best way to approach it.

Without a supporting rigorous approach (rigor at times being merely rigor mortis) or any delusions of essential defensibility, I suggest that in order to arrive at an improved pattern of engineering education for the year 2000 A.D. five steps be undertaken:

1. Operations Research

That a really major research project be undertaken on "Preparing for the Profession" from the operations research point of view. Operations research I recognize is a much misused, and a much maligned subject but in its proper place it does have very great merit. It deals with the investigation of complex and not completely analyzed situations, with whatever data and tools of logic are at hand in order to arrive at a framework for making optimum decisions for action. It is not a panacea and it is not magic, but certain methods and approaches have been worked out which are effective in complex situations where systems of both animate and inanimate objects are involved. Its greatest triumph was probably in optimizing the system for the air defense of England in the "Battle of Britain," in which, with the use of radar and observers and plotting boards and mathematical doctrines previously set up, the British were able to use their inadequate supply of interceptor aircraft to combat the flocks of German bombers and thus to come out victorious.

Similar success was scored, although not publicized as much, in the antisubmarine warfare. Operations research is now a major tool of military strategy and tactics and is becoming useful in a number of industrial systems and I believe it should have a certain effectiveness in the broad field of education, at least to the extent of delineating what the problems really are and indicating the probable optimum method of attack. In order to indicate what I mean by operations research, may I say that the analytical portion of this paper itself constitutes a sketchy and qualitative approach to the setting up of an operations research problem.

By making the above suggestion, I am implying that operations research may be more effective than research in methods of teaching—that rarified bailiwick of the pedagogue. My own feeling is that the "methods of teaching" approach deals with the problems in much too fine a structure. I also feel that traditional psychological experimentation is not particularly fruitful, because it attempts to be too exact and to put numbers on things which are really not susceptible to being pinned down to numbers. Both these activities may be necessary, but they are not sufficient.

I would also like to suggest, if anyone cares to listen, that this field of operations research in education for the professions would be a very worthy and eventually a very fruitful activity for some of the great philanthropic organizations, such as the Ford Foundation, which are very intent on extending their efforts on improving the human race.

II. Beginning While Young

The professions, particularly the engineering profession, should spearhead a movement to induce the objective teaching of science (for both sexes) from the kindergarten up. The most common characteristics of the youngsters is to ask "Why?". As parents and teachers we seem to be dedicated to suppressing this basic instinct of intellectual curiosity. By the time children arrive in high school, the job of suppression has usually been very thoroughly done. Why shouldn't we take every opportunity to cultivate and to encourage this really basic drive of intellectual curiosity and rationality? Not only would this most important motivation factor be kept alive, but by the time adolescence is reached the average individual might even have acquired a fair sized reservoir of knowledge of what the world is, and how it works. More important, there would be a real respect and understanding for the relation between cause and effect which is, of course, background of science and its application in engineering. As it is now, we have little to replace the vacuum which is left when the fairies pass out of the childish mind. As the years go on this emotional vacuum now tends to become filled with many curious things.

III. Atmosphere of Reality

More reality and fewer synthetic situations should be brought into the college teaching of engineering. This implies that there should be a much closer relation and effective liaison with commerce and industry and the other employers of engineers, throughout the teaching period than is the case at present. I am by no means convinced that the "co-op" engineering curricula, as presently constituted, are the answers but there are virtues there that should be explored.

As a rule, the medical profession probably does a better job of merging practice and teaching during the educational period than do the engineers. The "teaching hospital" concept, in which the medical student lives in the atmosphere of, and participates in varying degrees in the practice may have certain inherent virtues which engineering educators have been neglecting.

IV. Early Selection

Increased emphasis should be placed and encouragement given to earlier selection of careers when misfits come up during the educational period. Misfits are not just a matter of some persons being

stupid. We are all ignorant, but about different things. In my opinion, a great deal could be done—more than has beeen done in the past—on intuitive or measured selection and guidance of apparent misfits toward appropriate alternates. It is a very serious and often a very bitter thing to arrive at the point of no return in this educational journey of ours, and many are the mistakes that have been made because the career has been allowed to progress so far along a given course that it could not be altered.

V. The Continuation Function

After formal education is completed, the educational institution itself should move into industry and commerce, for continuation activities. In other words, university work does not end, or should not end, at the time of graduation. Educational paths are actually never completed as far as the truly professional man is concerned. The craft is "so long to learn" that the chore is never actually finished. Adult education, if you choose, or cooperation with industry, whatever may be involved, I feel should be an essential part of continuing professional education, especially engineering. One sees elements of it here and there, particularly in the state supported universities but, thus far, there is only a feeble beginning.

Perhaps one or more of those suggestions may make sense to some. Whether they do or not, I feel that I must leave the subject at this point. I admit that it is unsportsmanlike to leave the whole matter dangling (like the well-known participle) and ignore the details, but first you catch your hare and then decide how to make the rabbit soup. If this constitutes catching the hare or even a portion of him, it is probably sufficient work for one evening. If ideas have any basic merit in the minds of enough people, something will eventually be done about the details.

The suggestions I make run counter to the long standing tradition that engineering education is merely a four, five or six year stint. I believe it should essentially stretch almost from the cradle to the grave.

I am also implying that industry and commerce should move from their traditionally remote positions, isolated from the educational world. This will cost money and executive effort, but corporate stockholders had better get used to the idea, that is, if they really believe in the basic virtues of a free and reasonably individualistic economy. I still believe in those basic virtues myself but I think their survival will depend to a major degree on a truly effective and material collaboration and rapport between education and the vital, producing units of industry and commerce. It may be a losing battle but I am reasonably optimistic and hope I may still be around in 2000 A.D. to see if my optimism has been justified.

In the News

Ralph Morgen, Director of the **University of Florida's** Engineering and Industrial Experiment Station since 1947 has resigned to accept a position with the **National Science Foundation.** Dr. Morgen's position with the National Science Foundation will be to direct the engineering and metallurgical phase of the program.

Fourteen post-graduate fellowships and 19 scholarships will be offered by the **Radio Corporation of America** for the 1952–1953 academic year under an expanded and revised scholarship program, Dr. C. B. Jolliffe, Vice President and Technical Director of RCA, announced. Total amount of the awards, according to Dr. Jolliffe, will be $53,000, a substantial increase over previous years. This amount reflects RCA's expanded program of helping young engineers and scientists by means of seven new scholarships and one fellowship. It was also pointed out that the annual stipends for RCA Scholarships have been increased from $600 to $800.

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
*Allegheny	West Virginia University		C. H. Cather, West Virginia University
Illinois-Indiana	Rose Polytechnic Institute	May, 16, 1953	H. A. Moench, Rose Polytechnic Institute
Kansas-Nebraska	University of Kansas	Oct. 24–25, 1952	M. A. Durland, Kansas State College
Michigan	Detroit Institute of Technology	May 9, 1953	C. C. Winn, Detroit Institute of Technology
Middle Atlantic	Manhattan College	December 6, 1952	W. B. Plank, Lafayette College
Missouri	Washington University	April 11, 1953	G. F. Branigan, University of Arkansas
National Capital Area	Catholic University of America	Oct. 7, 1952	L. K. Downing, Howard University
	Howard University	May 9, 1953	
	University of Maryland	Feb. 3, 1953	
New England	Worcester Polytechnic Institute	Oct. 18, 1952	E. T. Donovan, University of New Hampshire
North Midwest	Iowa State College	Oct. 3–4, 1952	S. J. Chamberlin, Iowa State College
*Ohio	University of Cincinnati	April, 1953	H. K. Justice, University of Cincinnati
*Pacific Northwest	Washington State College	Spring, 1953	J. P. Spielman, Washington State College
Pacific Southwest	California State Polytechnic College	Dec. 29–30, 1952	C. E. Cherry, College of Marin
*Rocky Mountain	University of Wyoming	April 19, 1952	C. A. Hutchinson, University of Colorado
*Southeastern	Louisiana State University	March, 1953	D. V. Terrell, University of Kentucky
Southwestern	University of New Mexico	April 3 & 4, 1953	M. L. Ray, University of Houston
Upper New York	Alfred University	October 10–11, 1952	R. M. Campbell, Alfred University

Members of the Society are welcome at all Section Meetings

* No Date Set.

AMERICAN SOCIETY FOR ENGINEERING EDUCATION

April 6, 1952

To Members of the General Council

Gentlemen:

Your Committee on Improvement of Teaching, authorized by action of the Council at its meeting of June 24, 1949, at Rensselaer Polytechnic Institute, was first organized as a steering committee during the summer of 1949 and later, in the summer of 1950, was constituted in its present form. There have been two meetings of the full membership, and each of its three groups have held meetings of their own. Important and closely coordinated work has been carried out through the institutional committees, which were organized in over one hundred colleges and universities. More than 150 reports and criticisms have been received from these local committees. These communications have clearly illustrated the many active reviews of teaching methods and the efforts being made to bring about improvements. Your central committee is greatly indebted to these institutional groups for their participation, criticisms, and suggestions.

We believe that this cooperative effort between the schools should be a continuing enterprise and that it should be a primary activity of the ASEE Division on Educational Methods. We recommend that the matter of continuation of the process of improvement of teaching be referred to that Division for study and action, and we further recommend that, with the presentation of this report, the Committee on Improvement of Teaching be discharged.

Sincerely yours,

L. E. Grinter, *Chairman*

H. H. Armsby
A. B. Bronwell
H. W. Barlow
J. F. Calvert
J. W. Cell
N. A. Christensen
A. P. Colburn
N. W. Dougherty
E. E. Dreese
C. G. Duncombe
R. Eliassen
W. L. Everitt
R. E. Fadum
L. E. Grinter
H. P. Hammond
G. A. Hawkins
T. J. Higgins
E. Hutchisson
R. R. Jenness
R. A. Kliphardt
F. C. Lindvall
L. C. Maugh
K. B. McEachron, Jr.
B. V. Moore
P. Nudd
S. P. Olmsted
F. H. Pumphrey
H. S. Rogers
T. Saville
J. F. Smith
H. L. Solberg
R. L. Sweigert
B. R. Teare
H. Torgersen
M. Tribus
E. A. Walker
E. Weber
J. G. Woodburn

Improvement of Engineering Teaching

Report of the Committee on Improvement of Teaching

I. SUMMARY

This study was designed to bring about discussion of teaching methods and ways of learning in engineering faculties throughout the country, and to present in report form a number of the factors believed to be important in the improvement of teaching. The primary objective of this study has been to consider how to prepare students to meet new situations with skill, resourcefulness and leadership. Such preparation requires of the staff an understanding of the principles of teaching and learning, an appreciation of means for developing resourcefulness and originality, and continuing study of the most effective ways to achieve coordination of instruction.

Other objectives have been to consider how to instill in the student the desire to continue to learn after graduation, and how to provide a cultural foundation which will encourage him to contribute to his local community and to civic groups as a mature, thinking, human individual. The findings presented represent the opinions of many in engineering teaching.

Principles of learning stress the importance of effective participation on the part of the learner; his motivation through the formulation of a goal; the clear definition of task assignments (preferably defined by the student himself); the evaluation of his progress; and his repeated practice in application. To raise the level of what the student does, it is emphasized that teaching should be from basic laws of science rather than from relatively specialized derived formulas. To a great degree, problems should involve the application of basic laws to real situations, and require student initiative in attack. Many of the basic laws apply in a number of engineering fields, and important opportunities exist for stressing these interrelated applications.

Much more attention can be given profitably to the development of the student's originality and resourcefulness in order to prepare him for the thought processes required in professional work. In the report, techniques are suggested for the development and presentation of new and unfamiliar situations in the shop, classroom, and laboratory. Consideration is given to seminars, elective courses, independent studies and to research experience. The project method of instruction, utilizing problems of comprehensive scope, is advocated as an attractive means of developing resourcefulness, and of implementing effective student activity. This method places the student more on his own responsibility and gives him experience in planning in contradistinction to the execution of prescribed operations.

Engineering education provides the opportunity for related approaches in classroom, laboratory, and design work. Full opportunity should be taken to coordinate these approaches. Similarly, the social-humanistic stem can become more meaningful to the engineering student by coordination with the technical studies. The rotation of instructors among the various subjects which come within their general professional field is recommended. Intelligently employed, this practice develops broader acquaintance with subject matter and promotes course coordination.

The teacher is the key factor in efforts to improve education. This should be fully appreciated by every administrative officer and should find expression in three major ways: (1) recruiting the most promising teachers; (2) recognizing good teaching in the most effective manner—advancement and adequate compensation; and (3) developing a specific plan for

staff and committee discussions on methods of improving teaching so that the young instructor may benefit from the experiences of mature staff members.

Teaching loads should be kept within prescribed limits in order to permit teachers at all levels to engage in creative research and other activities contributing to their professional development.

The present concerted movement to improve the quality of engineering instruction should be a continuing effort, and the Committee suggests that institutional committees be a continuing activity under the guidance of the Educational Methods Division. In addition, special schools might well be established for the specific purposes of aiding engineering teachers in the improvement of their methods of instruction and in the development of new methods through research and experiment.

II. INTRODUCTION

The study on which this report is based originated from the belief that while two comprehensive reports by committees of the Society—*Aims and Scope of Engineering Curricula* (1940) [1] and *Engineering Education After the War* (1944) [2]—have influenced engineering education by stating its fundamental objectives and recommending better means for attaining them, the findings of these earlier reports could become widely effective only if they would influence directly the center of engineering education—the student and teacher in the classroom. The Committee on Improvement of Teaching, which presents this report, was appointed to aid in accomplishing this result. The fundamental method of the Committee has been to stimulate discussion of teaching methods and their betterment in institutions throughout the country. More than one hundred faculty committees were appointed for this purpose and more than 150 reports, comments, and suggestions have been received.

This Committee has previously issued two preliminary reports based in large measure on the communications received from local faculty groups. These two reports have been circulated to all accredited engineering colleges throughout the country where they were discussed and criticisms were formulated . The responses are notable for frankness and discernment both with reference to local conditions and also to general conditions prevailing throughout engineering education. This final report is based to a very considerable degree on the communications received from the faculty discussion groups. It is this Committee's opinion that a wise college adminstration will find ways to expand the influence of these discussion groups to include a larger proportion of the engineering faculty, particularly the younger members.

It is vitally important that each institution decide how to place emphasis upon those factors that influence the quality of teaching. The first requirement is that the president, dean, and department heads value good teaching and make this fact known. They carry the responsibility for counselling with their staffs regarding the effectiveness of teaching. How this may be done best is a local problem and a matter of individual judgment.

Discussion groups appointed from young teachers, from departmental faculties, from the faculties of related departments, from teachers interested in laboratory instruction, from those with special interests in written or oral expression, or from teachers drawn together by any common interest can have a vitalizing influence upon faculty morale and the effectiveness of teaching within the institution. Since many group interests may be encouraged and since faculties change continually, discussions on improvement of teaching should be made a live part of the continuing operation of every engineering faculty.

[1] *Journal of Engineering Education*, Vol. XXX, No. 7, March, 1940.

[2] *Journal of Engineering Education*, Vol. XXXV, No. 1, September, 1944.

III. OBJECTIVES OF ENGINEERING EDUCATION

Engineering education has been variously described as a profession, an art, a science, and a business. It is all of these, but primarily it is the profession in which men apply the known principles of the physical sciences creatively for the general good of society. The objectives of engineering education can be summarized as follows:

(1) To develop the student professionally so that he can make distinctive contributions to the welfare of society. An engineering student must be prepared continually to face new problems which call for skill, initiative, and leadership. He must project from past experience into new situations and must do so both with a sense of responsibility and with confidence in his ability to find an acceptable solution. Thus, with technical ability must be coupled economic judgment and an appreciation of social values conditioned by the specific requirements of the problem.

(2) To instill in the student the desire continually to progress professionally and to expand his knowledge and abilities. Professional progress may be achieved in any one of several directions, such as research, development, design, production, construction, sales, or education. Each requires a different emphasis of formal or informal study after graduation. The student should be guided to recognize his strengths that he may cultivate them, and his weaknessses that he may endeavor to overcome them.

(3) To provide a cultural foundation which will enable the student to comprehend economic and social problems and which will encourage him to contribute constructively to his local community and to civil groups as a mature, thinking, human individual.

In sum, the purpose of engineering instruction is epitomized in the statement by Warren K. Lewis, who said, "Our objective is the development of the capacity of the student when faced with a new and unfamiliar situation, to handle it with competence involving skill, initiative, and leadership."

IV. PRINCIPLES OF TEACHING AND LEARNING

A. Principles of Learning

As background it may be well to bring together a number of the basic principles of learning. A few are listed here for convenience:

1. *Learning is a process by which increasing ability is developed through the effective activity of the learner.* The learner must think through the idea to be understood, or perform the act in which he is to develop skill. Learning is not a passive process of absorption, but comes only through active participation. The lecture method of teaching all too often reduces the student to the role of an inactive observer, whose mental processes labor along at subnormal efficiencies. The zest and enthusiasm engendered by active participation in live problems are often much more effective in developing the student's potential capacities.

2. *The learner must have a goal.* Learning takes place only when the learner is trying to reach an objective. He must be motivated. The more desirable the goal, the more immediate and realistic it is, the stronger is the motivation to learn.

3. *Objectives for task assignments should be as clear and as immediate as possible.* The goals or objectives to be achieved and the lesson assignments or tasks should be clearly defined. The objectives should not be merely some distant or vague goal, but should be as definite and as immediate as possible. This does not mean that the specific steps or the methods of procedure are to be given. Part of the assignment might well be to require the student to define clearly his own goals before proceeding in the solution of the problem.

4. *The learner must know wherein he succeeds or fails.* Since, for effective learning, the student must *strive* to solve a problem or to acquire knowledge and skill, he must know promptly what progress he has made and precisely where he has failed. Routine drill without knowledge of results destroys zeal for learning. The good elements of a product should be recognized and praised, and only the specific defects, rather than the whole, should be adversely criticized. Fewer assigned problems, but all of these more carefully prepared and corrected, result in better learning. There are inherent values in having the student identify his products as his own creation. It is quite instructive for the student to evaluate, regularly and critically, his own degree of success or failure.

5. *True education requires understanding and mastery of the material to be learned.* This means insight into the fundamental laws or principles and proceeding from them to the formulas applying to a particular situation. Insight is developed by proceeding from the known to the unknown, from old concepts to new ones, from simple problems solved by one principle to complex problems involving more than one law or principle. This develops solid growth, insight and power in the use of basic principles, it gives to the student confidence, and it leads to initiative and originality in meeting new situations.

6. *Repeated practice in different applications is essential.* Repeated successful practice is better than fewer prolonged learning periods. A new idea should be repeated several times in different relationships and applications. These repetitions should not be routine, but each should reach a successively higher level.

B. Mastery vs. Coverage

Engineering is not easy. For success it demands hard, purposeful work. Resourcefulness, and at times, inspiration, are needed, but for continuing professional success there must always be present the ability to work hard, intelligently and purposefully.

The Committee believes, however, that in engineering education entirely too much time is spent on profitless, repetitive, routine assignments. This is not to say that practice is not needed to develop skills, but rather to suggest that a close survey of curricula will disclose time spent that might be better devoted to other purposes. In particular, the question may be asked whether a good many so-called problems really are problems in the sense that they require constructive thought and the development of judgment. All too often they merely require the following of a pattern of solution already illustrated or the substitution in a formula already derived.

Under pressure to cover ground, all engineering curricula have been so designed that they require the student to pursue knowledge and ability simultaneously in a considerable number and variety of subjects. Often this is done at some sacrifice of thoroughness, mastery of fundamentals, training in accuracy, or the development of facility for written and oral expression. Improvement needs to be made by concentrating the student's efforts on a smaller field of coverage, in order better to develop his command over fundamental laws and their uses, to increase his resourcefulness to face new and untried situations, and to improve his ability to express himself. In a word, to do less but to do it better is a desirable aim of engineering education for the immediate future.

C. Teaching from Basic Laws

The terms "basic laws" and "derived formulas" are relative rather than absolute. Generally speaking, basic laws are the mathematical statements of fundamental scientific principles. Derived formulas, developed from the basic laws, often apply only to limited areas of engineering practice. The basic laws commonly employed in any given area of en-

gineering are not numerous, and are the true building blocks of engineering, both at the educational and the professional levels.

Insight into the basic laws and their physical meaning can be of inestimable value since it helps the student gain a sound conceptual understanding of his engineering subjects. Basic laws are also indispensable to the engineer in dealing with new problems. As the engineer achieves professional stature, the old laws will take on new meanings and he will learn new basic laws, which, combined with the old, will give him a deeper insight into the foundations of engineering than is possible even from an extensive knowledge of derived formulas. These derived formulas and accepted practices so necessary in specific engineering applications should be derived, whenever possible, from the basic laws of science.

It follows that problem assignments should, in so far as possible, require the student to arrive at conclusions by the use of basic laws. It is also instructive to assign problems in which the student derives or extends the applications of one of these laws. It may be worthy of mention that numerical or graphical solutions may often proceed directly from basic laws to end results without need of derived formulas as an intermediate step of analysis.

Many of the principles which we consider basic in engineering today existed only in the realm of pure mathematics or physics a quarter of a century ago. In view of the spectacular progress being made in physics and engineering, it seems inevitable that new basic laws will be introduced in the undergraduate curriculum in the years to come. It is the responsibility of the instructor to seek these out and to present them to the student in understandable and usable forms.

Closely related to the need for emphasis on basic laws is the importance of coordinating the subject material of various engineering courses through their employment in many parts of the curriculum.

D. Engineering—An Expanding Body of Knowledge

Engineering and science should be taught as a dynamic body of knowledge, which is constantly expanding. Students are vitally interested in knowing something about the limits of present-day knowledge, the directions of expansion, and the probable frontiers of the future. An undergraduate course which conveys the impression that all knowledge of the subject is known and that there are no frontiers of development is sterile and uninteresting.

E. Student Participation in His Learning Process

Successful teachers give careful consideration to methods of stimulating interest and arousing the student's enthusiasm in the subject. These can best be developed by a method of teaching which brings the student into active participation in his learning process and which gives him ample opportunity to express his ideas. For example, the teacher might start the class by proposing a specific problem, to illustrate a fundamental principle, and then solicit suggestions from the students on methods of attack. This in all probability will result in a stimulating discussion with considerable zest and enthusiasm for finding a solution. This method serves to develop sound and logical thinking, ability for self-expression, and a high degree of motivation, since the student's rather than the teacher's ideas appear to be the focal points of the discussion. However, this method of instruction requires careful planning and skilful guidance if desired objectives are to be attained.

The principal limitation in the student participation plan is that it is difficult to maintain the same rate of progress as in the purely lecture type of course in which the instructor presents the material in an orderly, logical pattern. It may therefore be desirable to use both methods in appropriate proportions—the lecture

method, with some opportunity for informal student comment, to give a clear understanding of basic principles, and also the student participation method, to illustrate applications of these principles. This advances the student's knowledge rapidly yet permits him to develop both his individual capacities and his ability to contribute through group discussions.

Wherever possible, the problems should deal with real situations so that motivation is provided by a sense of accomplishment when a student reaches a conclusion. The problems should be directed also toward the goal of learning to deal with new situations, using basic principles, rather than merely in obtaining numerical solutions by use of derived formulas.

F. Training in Accuracy

Frequently students are not trained to develop habits of accuracy in their work. They should realize that mistakes involving life or dollars cannot be tolerated in engineering practice and that they must develop habits of accuracy not only in their initial computations, but must *always* check their work. They must learn also to size up their work to see whether, from the data and conditions, results are reasonable and that there is dimensional homogeneity throughout the quantities of an equation.

V. DEVELOPMENT OF RESOURCEFULNESS AND ORIGINALITY

At times we lose sight of the latent possibilities for creative work possessed by engineering students. There is evidence that all levels and kinds of creative ability may be found, and that through training directed to that end, the powers of an individual may be enhanced much more than is commonly supposed.

In a qualitative sense, perhaps *originality* is the best single word to describe the abilities with which we are concerned, though the terms ingenuity, inventiveness, and creativity are also descriptive of the qualities with which we are dealing. Resourcefulness, which is a characteristic of all successful engineers, is closely related to originality.

It is believed that the engineer will progress best if, before leaving college, he is given certain principles and practices related to original work. These will be concerned with alertness for the discovery of new problems and new facts and with facility for dealing with unfamiliar situations. He needs to develop: a method and habit for clearly stating objectives, idea fluency in proposing solutions, a skill for matching the probable results of such proposals against the desired objectives, and an ability to negotiate the acceptance of his ideas.

A. Steps in Creative Problem Solving

The practicing engineer is concerned with problems which do not come to him neatly packaged under the sequential heading of "Given" and "Find." He is concerned with the much more general arts of discovering and defining problems as well as with solving them.

Let us consider three questions:

(1) Where do problems come from?
(2) What do people do with them? and
(3) What should the engineer do with them?

A complete engineering problem calls for its statement both in terms of a human want and in terms of certain physical results. The latter become the goals which, if achieved, it is believed will satisfy the want. In endeavoring to solve a problem, the engineer may try to find a new combination of old ideas; or he may seek to discover new ideas or facts which, when appropriately combined, yield a desired result.

The four parts to engineering problem solving may be stated as follows:

1. *Discovering a Human Want* [3]

The statement of a problem is preceded by the existence of a human want. With the engineer this should lead to a kind of

[3] As used here, "want" implies many things of which physical goods may be only a single classification.

optimistic discontent. The engineer who does not have the urge to do things differently and better is not likely to invent. He should feel that he must state problems accurately and that he will find solutions if they are sufficiently justified.

2. *Statement of Goal*

In endeavoring to make a concise statement of a problem, one might start by listing all factors which seem to have a bearing on it. Through classification and consolidation, an effort should be made to extract from these factors a statement somewhat of the following form:

(a) The purpose is to produce (if a design is called for).....
or the purpose is to determine (if an analysis is needed).....
(b) To overcome the specific obstacles of.....
(c) in such a way that.....

Under item (a) could be listed a device or test. Under (b) could be stated any related restrictions. The latter might include undesirable features of the present-day situation or equipment. There might be, and often is, the question "Why do it this way?". It might also include difficulties to be encountered in negotiating the acceptance of a solution. Under (c) could be placed all manner of specifications. Besides the usual ones of cost, size, weight and performance characteristics, other criteria may be necessary in the initial stages of a development. Thus, if a hitherto unseen device or material is called for, a list of minimum acceptable criteria may be needed. However, if more than one set of physical results will satisfy minimum criteria, there may be required a weighted grading system concerned with how any or all sets of physical results exceed the minimum requirements. On such a basis the engineer decides which of several procedures he should carry forward.

3. *The Incubation Period*

Suitable combinations of idea elements for the solution of a problem usually do not just hatch. If the problem is difficult, this period will be one of great effort characterized by considerable frustration and indecision.

One of the greatest difficulties is that winning combinations are often too elaborate for the mind to include in a single span of comprehension. However, students should learn that if the necessary individual elements can be listed, a large problem may be reduced to a series of smaller ones which may be solved one at a time. A continuing effort so to reduce the major problem is a means of avoiding confusion and frustration.

Closely related to the foregoing is the fact that needed idea elements often are not brought forth because they are embedded in the memory of different situations where they were first learned and applied. The disassociation of such knowledge, so that the pertinent parts may be transferred to the new problem, represents a difficult feat. Correlation of courses in accord with basic laws gives a helpful background for the transfer of ideas. The ability to draw analogies is also a powerful device and its use may be developed. It may be desirable at times to take a rest from part or even all of the problem in order that useless ideas may fade out of one's consciousness.

Other common difficulties of the incubation period are:

(a) Presumed pertinent facts are only partially true, or even totally untrue. Those which are only partially correct seem to be the most difficult with which to deal.

(b) Perhaps not enough data are available to solve the problem.

(c) When a potential solution has been found, it is not time to stop; modifications and alternate solutions often can be found. Since engineering is a highly competitive field, it is important to look for the best solution, and also to stake out avenues for improvements which permit later development.

4. *Final Negotiations*

To capitalize on any problem solution, it is generally necessary to negotiate its

acceptance. Usually the young engineer is shocked to discover that he has not only to do the job, but to persuade others to accept his ideas; and at times he is more than shocked to find that the man who presented him with the original task is often his severest critic.

5. *Summary of Traits Required for Original Work*

The following personal characteristics and abilities seem to be essential for creative engineering accomplishments:

(a) Personal characteristics:
1. Active desire to achieve.
2. Optimistic discontent.
3. Directed curiosity.
4. Memory for basic facts and for the data pertinent to the present work.
5. Imagery—the ability to visualize in two and three dimensions, and in symbolic notations.
6. Logical thinking—to check for both matches and mismatches between the results of a given combination and those required by the stated goals.

(b) Abilities:
1. To state the problem.
2. To reduce it to a series of small goals.
3. To associate idea elements and to reevaluate the requirements.
4. To work hard, to discuss, etc., and to set the stage for the appearance of the winning combination even if this calls for the complete abandonment of the problem for a period of time.

B. Reflected Problems in Engineering Education

Problem work which calls for facility with new and unfamiliar situations should be included in the undergraduate curriculum. Motivation for such activity is an item of primary importance and a theme which should be carried through all four years of study. However, the abilities and work methods of the creative engineer can be broken down into components in such a way that many of the present college courses can be made to contribute much more than they often do to the development of the student's capacity for dealing with new and unfamiliar situations. The following are suggested as some of the curricular possibilities.

C. The Project Method

This is probably the most valuable of the methods that may be used to develop originality and resourcefulness.

By "project method" is meant the use of problems of more comprehensive scope than those of the usual type employed in introductory courses which involve only a single element or operation. Projects may range from simple situations which may be used to introduce the method in the lower years to those for more mature students which are of larger scale and more complex nature involving search for the principles involved. Only a few projects of major scope might be assigned in a semester. The undergraduate thesis or senior seminar paper should represent the culmination of this method of instruction.

In the project method, as in the solution of most engineering problems, the student is required to:

(1) Identify and define the whole problem.
(2) Plan the solution.
(3) Choose the analytical methods and tools of solution and carry out the plan.
(4) Test the results.
(5) Evaluate the process and draw conclusions.

1. *Educational Gains from Use of the Project Method*

The project method is more costly than the customary classroom-laboratory method in terms of student and instructor time and of laboratory equipment. If used to an appreciable extent it means also that the student will cover less ground

Failure to cover quite as much ground, provided the student will not lack essential knowledge, should not be considered adverse to the project method. The end result should be better mastery of fundamental principles and greater confidence and skill in their use.

The project method places the student more on his own responsibility than do methods of instruction more commonly used. The student must, of course, be given help when he really needs it. Some floundering can provide beneficial experience. A major purpose of the project method is to give the student a sample, even if a small one, of the way he will meet conditions after graduation. It is intended also to serve as a means of breaking the lockstep of work assigned in small daily installments from period to period and from examination to examination, a practice that often seems to extend from the time of entry until graduation.

The Committee believes that entirely too much of the student's time is consumed in repetitive, routine jobs. It is true that practice is needed to develop skills. However, a close survey of many courses would reveal that a substantial amount of time could be devoted more profitably to other purposes. In particular, the question might be asked: How much of the problem assignment deals with exercises which merely require the following of a pattern of solution already illustrated or the substitution in a formula already derived?

While the project method can be used to good advantage to give the student experience in original and creative thinking in probably every engineering course, the following provides a few specific examples:

2. *Drawing, Shop and Kinematics*

Courses in drawing, shop, and kinematics could contribute significantly by including problems which require the student to exercise resourcefulness and ingenuity in putting various elements together to get a desired solution.

It may be assumed that the development of a three dimensional sense will prove as valuable to the engineer as will knowledge of shop techniques and the language of drawings. It is not too difficult to achieve reasonable ability in isometric and perspective line drawing. Transparent models and freehand drawings by students, using color to illustrate the various parts, have great educational value. A substantial amount of material has been catalogued on devices and mechanisms. The design principles embodied in these devices often prove to be the building blocks for new equipment.

3. *Classroom and Computing Periods*

Occasional lectures which describe specific creative work may arouse students to a desire to make contributions of their own. Many examples can be prepared in any field to show how engineering problems arose, how they were broken down into smaller problems, the obstacles which were met and how they were solved, and how the results became accepted. However, it should be clearly recognized that the student can develop his own creative abilities only by coming to grips with problems in which he himself is trying to be the originator or creator.

A few problems might be employed which include too much information and others which contain too little. Again a problem might be introduced containing an error in the engineering diagram. These would be of value because discrimination and reasoned assumptions are commonly called for in uncharted areas, and each may require resourcefulness or originality.

4. *Laboratory*

Laboratory work may be employed to substantiate theory which has been presented in texts and lectures. If the philosophy is adopted that, after the techniques are learned, one of the prime purposes of laboratory work is to develop self-reliance and ingenuity, then a great deal may be accomplished. Examples may be cited wherein only the end results are specified and a squad is permitted to plan the test, select the equipment and carry

out its own program. By such a process fewer experiments and write-ups will be completed, but engineers will be produced who can do more than follow stereotyped cook-book instructions.

5. *Seminar, Elective Courses and Independent Study*

Courses such as these, coming as they usually do in the senior year, may be designed explicitly to encourage originality. However, except for a small percentage of the students, neither enthusiasm nor results should be anticipated unless the students have been prepared for this sort of work during their earlier years of study. It is imperative to give the individual student broad latitude in selecting his own goals in order that he will develop the interest and drive necessary to carry such work to a successful conclusion.

6. *Research Projects*

It is often desirable to place promising undergraduates on full scale projects where they may assist staff members who are engaged in research. Much can be accomplished provided that intelligent attention is given to educational possibilities. The changes in viewpoint and the reasons for decision should be made quite clear to the students in order that they may learn to discriminate, to cut through the non-essential matters, and to develop engineering judgment.

VI. COORDINATION OF INSTRUCTION

An asset of engineering education is the opportunity to use several methods of instruction in a given field. Methods commonly employed are: the lecture-recitation procedure, which is used chiefly to aid the student in obtaining an understanding of basic laws; laboratory work, to strengthen such understanding and also to develop skill in experimental techniques; and design work, which is used both to show how engineering principles are applied in situations simulating practice and also to illustrate how principles from related fields can be combined to yield a solution.

A. Coordination between Engineering Courses

Coordination of methods of instruction means conducting courses in such a manner that the student sees the relationship between a subject as it is studied in the classroom and as it is applied in the laboratory or in design. In a single subject it is desirable to have recitation and laboratory work either simultaneously or in a planned sequence so that the student applies principles soon after he has studied them theoretically. This brings to him both a better understanding of the theory and a better appreciation of the limitations surrounding its use.

The opportunity to realize these aims varies with courses. The optimum realizable coordination of class and laboratory work probably occurs in chemistry, with physics and mechanics in nearly as favorable situations. In such courses as heat engineering and unit processes, which employ complex fixed equipment, it is more difficult to achieve close coordination. However, opportunities exist in courses even of the latter type to use relatively simple inexpensive equipment that may be duplicated to achieve better coordination with classroom work. When such equipment is used, the experimental work often can aid the student in mastering principles to even greater advantage than is possible with the more elaborate equipment.

Most of the major engineering laboratory work employs subject matter covered much earlier in preparatory courses. Numerous examples of this are to be found in chemical engineering unit operation laboratory courses. In these it is necessary that the work be so taught that the students will see clearly the relationship of the experiments to the principles previously taught either in the same or other departments.

One of the better opportunities for coordination lies in the field of materials of engineering. Recitations, laboratory and

design all consider the use of materials in machines, in process equipment, and in structures. Basic studies of materials occur in the shop, the materials testing laboratory, the course in strength of materials, and courses in metallurgy. Hence, instruction in materials is given in separate segments, yet not often as related parts of a major field. Here exists an opportunity for the instructor and student to realize that portions of the subject material in many courses form parts of the whole field of engineering materials.

B. Coordination with Humanistic-Social Courses

The foregoing relates expressly to coordination within the scientific-technological stem of the curriculum. There are opportunities to improve coordination of the technical and scientific with the humanistic-social courses. An example is in developing the art of expression. Students are most likely to understand and be impressed by the necessity for the use of clear expression if it is required in their engineering courses, and if they learn that sloppy writing or speaking is a serious handicap in engineering practice. Engineering curricula, because they require a great deal of report writing, offer many opportunities for additional training. Correction of faults in oral presentation in the classroom is as important as correction of written papers. But it should be emphasized that engineering teachers must take the prime responsibility for the good written and oral expression of their students.

There are also opportunities for the coordination of other humanistic-social subjects with scientific and technological subjects. Economics is one of these. As an example, every teacher of engineering knows that the advent of heat power as a means of doing work brought on a revolutionary change in our whole economic and social organization. There are opportunities to introduce many specific examples which show the impact of technology upon our present-day social-economic system and thereby to impress the student with the significance of his studies in economics.

However, in the attempt to achieve correlation, we should not expect to distort the studies of our students in the social science and humanities so that these become modified engineering courses. The social science and humanities courses are, in their own right, vital parts of the engineer's education. Their function is to give the student a mature viewpoint, gained through an increased knowledge of cultures and civilizations; an understanding of social and ethical concepts and their effects upon the present-day world; an insight into the origin and functioning of social and industrial institutions; as well as an understanding of economic principles in modern industrial society. They provide experience with different procedures for collecting data and different reasoned approaches to conclusions. They offer opportunities for enriched intellectual lives through the development of individual cultural interests. Any attempt to channel such courses into purely engineering areas will deprive our students of essential opportunities for development.

C. Educational Function of Examinations

It is often assumed that the major purpose of examinations is to evaluate the performance of students. Examinations do, of course, serve the purpose of keeping the student aware of the quality of his work and of acquainting him with his mistakes and weaknesses. The results of an examination may also acquaint the instructor with his own shortcomings as evidenced by his students' work. But these are only some of the values; if properly planned, examinations serve other important educational purposes. They can stimulate the student to review the course, thereby achieving a better organization in his mind of the subject matter. They place the student on his own responsibility and require him to think for himself. If so prepared, they may require him to use more than a single principle to solve a

problem and thus to synthesize his knowledge.

If administered by the open-book plan, examinations may require the solution of fairly comprehensive problems in which the student must bring to bear and hence correlate his knowledge of principles and data from more than one field. Examinations of this type will require a generous time allotment and some preparatory conditioning of the student, but they have educational value well beyond those used merely to inventory the student's knowledge. Open-book examinations are best adapted to upper class subjects but are not necessarily so limited. Teachers who have employed such examinations usually are convinced of their value as an integral part of the program for student development.

D. Rotation of Instructors

While practice differs, there is a tendency among departments to confine an instructor's work to a small group of related courses and to leave him on such a set of assignments indefinitely. This does not give him an opportunity to broaden either his technical interests or his evaluation of the program of the school as a whole. Also it does not bring to a given subject the benefits of fresh points of view. It is recognized that each department must have specialists, particularly at the higher levels, but some of these men might also enjoy the opportunity to "renew their youth" scholastically by teaching an introductory course from time to time. It is believed that there would be definite advantages in rotating instructors among the several introductory courses of a department, and even to extend this practice beyond departmental lines.

One of the best ways of achieving correlation of subject material in various courses is to rotate teachers among the courses that each may acquire a better overall picture of the structure and content of the curriculum. Ideas soon develop on how the material can be better correlated.

VII. DEVELOPMENT AND GROWTH OF TEACHERS

The teacher is the key factor in the efforts to improve teaching. Every administrative officer realizes his responsibility to recruit and retain a strong faculty. It is equally important for the dean and department head to aid his faculty to increase in effectiveness by individual and collective efforts; to provide opportunities for leaves of absence for advanced study or industrial employment; to provide opportunities for research; and in general to create an atmosphere favorable to progress. It is very important that there be a definitely understood policy to reward achievements in effective teaching.

A. Organizing an Engineering Faculty for Improvement of Teaching

Continuous organization for the improvement of engineering education should be a normal faculty function. It is believed that the value of the work of the institutional committees, whose contributions are so largely reflected in this report, bears out this claim. Such organizations may take several forms. Through formal meetings younger staff members may meet with the dean, department chairmen, and senior staff members. Members of the staff of the School of Education should be invited to present some matters of basic importance to teachers. Informal meetings of staff members may be instituted for the discussion either of problems related to specific courses or for the consideration of more general educational problems. Successful teaching is a skilled art, and one in which the new instructor can profit immeasurably from the experiences of others.

Somewhat less formally organized methods may be employed. A practice sometimes used is to assign a younger teacher to an experienced faculty member, so that the younger man may audit a course, follow the methods employed and thoughtfully consider the development of his own procedures. In addition it may be well for a younger teacher to invite a more ex-

perienced staff member to audit his work in order that the young teacher may gain from suggestions and constructive criticism.

The benefits of cross fertilization are well recognized. Visiting professors should be sought—particularly those who are known to be excellent teachers and those who have new methods or new material to present. They afford other staff members the opportunity for auditing and observing. The use of men from industry, who come to the colleges either for short or for extended periods of time, may bring to the colleges fresh view points. The latter procedure may have much the same value as the experience which staff members gain through part-time employment in a single industrial department.

The scheme of encouraging the appointment of institutional committees for improvement of teaching, which has been promoted by this committee through ASEE, has proved useful because the institutional committee is formal enough to be recognized and still informal enough to work under its own initiative. The fact that there is a committee doing something about improvement of teaching will direct attention to the problem and stimulate interest in it. If these committees identify good techniques in each of the schools, a very considerable improvement may be achieved. The fact that more than a thousand engineering teachers have taken part in such formal discussions during the past year is a matter of great importance to engineering education.

B. The Development of Instructors

This portion of the report is based upon answers obtained to a number of questions submitted to a selected group of experienced teachers. The questions dealt with intra-departmental methods of developing young instructors and represent a cross-section of opinion and experience. It is to be noted that a significant number of institutions is making systematic efforts to assist the younger teachers to improve their work.

1. Frequent meetings are conducted during a term for both new and experienced teachers giving the same course. They gather to discuss objectives of instruction, methods of presentation, etc.

2. New teachers meet each week with an experienced teacher acting as chairman. They are likely to be teaching the same courses and take turns presenting some of the material of the next week's classes, while others criticize and ask questions. The senior member is chary of criticizing, but by means of questions brings out the fact that there are more ways than one to present the topic. This method induces very careful preparation several days before a given subject is introduced to the student.

3. New teachers are encouraged to bring their teaching problems to senior members. Each junior staff member may thus pay weekly visits to a senior member for guidance and counsel. The senior member may be assigned by the chairman of the department, or he may be chosen by the junior member. The new teacher needs a maximum amount of encouragement, and a minimum of supervision.

4. The work of the new teacher is regularly supervised by a senior member. Together they plan and discuss the weekly schedule of material, quiz making, and methods of grading. They may also arrange to exchange class visitations.

C. Recognition of Good Teaching

As a fundamental policy, too often not observed, good teaching should be recognized and rewarded. Rewards should include the tangible form of promotion and increase in salary. Good teaching is not always accompanied by research or publications, though these are earmarks of a progressive spirit that is often reflected in inspired teaching. It is very important that it be known universally among staff members that good teaching *per se* is watched for and will be recognized and rewarded just as is authorship and research.

If many of the improvements of teaching that are advocated in this report are

to be adopted, both teaching and study loads must be held within limits that will permit instructors to devote sufficient time to the development and broadening of their experience. This remark does not apply to research in institutions that systematically compensate for time so applied by proportionally reducing teaching loads, but it does apply to excessive teaching loads, either as measured by number of class hours per week or by number of students per instructor or both. General observation supports the conclusion that, in general, teaching loads in engineering are too heavy either as measured on a scale involving amount of time available for constructive improvement of teaching or in comparison with other fields of instruction.

VIII. RECOMMENDATIONS

A. Continuation of Committees

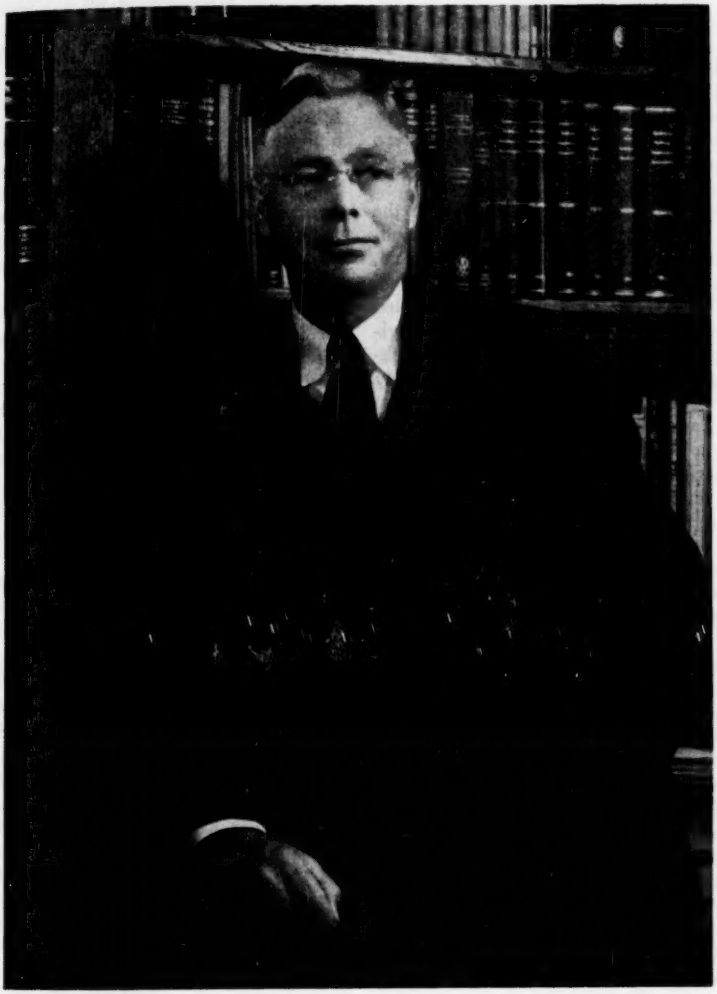
This Committee recognizes that a concerted movement to improve the quality of instruction in engineering colleges must be a continuing effort. The success of the present program to enlist the cooperation of faculties throughout the country lends much encouragement to the hope that this undertaking may continue during many years to come. Engineering teachers agree that teaching can be improved. Engineering education is not static; it is dynamic. Constant changes in science and in the art of engineering practice bring new requirements and opportunities. It is important that these efforts at self-appraisal continue, and it is even more important that they should be reflected by continuing efforts to bring about improvements in the real center of engineering education, which is the classroom.

This Committee suggests, therefore, that institutional committees, such as were appointed to cooperate in the preparation of this report—possibly with rotating membership—be a continuing function of each engineering college. It also recommends that each engineering college adopt for itself a definite plan to assist the young teacher in developing more effective teaching methods achieving professional growth. These factors are far too important to the institution to be left to unguided chance development.

B. Schools for Engineering Teachers

As an additional recommendation, this Committee proposes, in accordance with suggestions from correspondents, that special schools or postgraduate training programs for the specific purpose of aiding teachers to improve their methods of instruction be established in strategically located institutions. These postgraduate programs must have strong staffs in engineering, science, and the humanistic-social studies relating to engineering, as well as teachers either from faculties of education or selected from the engineering group because of their known skill in teaching. It is hoped that if such schools can be established, means can be found for aiding teachers financially so that they can attend for an academic year. One possibility is that of granting a leave of absence with salary; another is the subvention from an educational foundation. It is suggested that the sponsoring institutions offer academic credit and a suitable advanced degree for successful completion of the program. Programs combining such work in education with subject matter courses in engineering or administration would serve a very useful purpose. Opportunities must be provided for suitable research which may be related either to educational methods, the correlation of knowledge, in addition to the more conventional types of work in specialized areas of engineering and applied science.

Lamme Award—1952—Solomon Cady Hollister



To SOLOMON CADY HOLLISTER *for his excellent work in stating the functions of engineering education and his dynamic leadership in putting them into practice; for his untiring efforts in bringing to public notice the great need for engineers and the necessity for using them to their greatest efficiency; for his achievements as a teacher, a consulting engineer, a research worker and an engineering educational administrator, we award this the 25th Lamme Medal.*

SOLOMON CADY HOLLISTER was born in Crystal Falls, Michigan, on August 4, 1891, the son of Solomon Davis and Mary Runkel Hollister. The family moved westward to the State of Washington in his early youth, bringing to him an experience that still holds many vivid memories. Although his career has brought him again to the East, many of Dean Hollister's associates will credit him with a Western viewpoint—full-scale and distinctly three-dimensional.

His collegiate training started at the State College of Washington and was continued at the University of Wisconsin, where he received the B.S. in C.E. in 1916 and the C.E. in 1932. He was awarded the honorary degree of Doctor of Engineering by Stevens Institute of Technology in 1942, and is being similarly honored this year by his alma mater, Wisconsin, with the Doctor of Science degree.

For a period of some fifteen years after graduation Dr. Hollister engaged in a wide range of professional practice, including an initial venture in the academic world as an instructor in mechanics at the University of Illinois in 1916–17.

It was at this time that reinforced concrete construction was emerging from the status of a somewhat unpredictable art to that of a structural science. Dean Hollister soon became associated with several of the major activities in this field. By 1918 he was a member of the Joint Committee on Standard Specifications for Concrete and Reinforced Concrete, and in 1919–20 he served as chief design engineer and head, Investigation Branch, Concrete Ship Section of the U. S. Shipping Board. Although his career has since taken him into various other engineering interests, he has maintained a close affinity with concrete technology as a teacher, consultant, and member of numerous technical groups in the field. His long association with the American Concrete Institute includes several committee chairmanships and two terms as president, 1932–1934.

Of his many publications a good number deal with concrete and structural design, including an A.C.I. Wason Research Medal paper on the design and construction of a skew arch bridge.

As a consulting engineer in the 1920's he became interested in the potentialities and problems of structural welding. He undertook the development of the more vigorous methods of stress analysis and engineering control required in welded fabrication. This interest, in turn, led him back to the academic scene in 1930, when he was appointed Professor of Structural Engineering and Assistant Director of the Testing Materials Laboratory at Purdue. His work on photoelastic methods of analysis led to his appointment as consulting engineer to Babcock and Wilcox on the design and fabrication of the Hoover Dam penstocks. He has since carried out a number of assignments for this company on high pressure boiler design. Other consulting activities with industry and government agencies have covered a wide range of engineering problems. During this period he also conducted research on the transit mixer which became the basis of specifications for concrete mixed in this manner.

In 1934 he came to Cornell as Director of the School of Civil Engineering, and in 1937 he was appointed Dean of the College of Engineering. He has since devoted much time to educational development, and particularly to the relation of engineering education to the profession. At Cornell, the five-year undergraduate engineering curricula are one expression of the resultant philosophy.

His years at Cornell have been both challenging and rewarding. He has won the enthusiastic support of the alumni, and this, coupled with the will of his colleagues on the campus, has made possible both educational advancement and physical development of considerable magnitude despite the disruption of the war years.

Since his association with the academic world, Dean Hollister has had an increasing range of opportunity for stimulating service to engineering education. Among his major responsibilities in recent years

have been the chairmanship of the Education Committee of Engineers' Council for Professional Development; also of the Subcommittee on Graduate Education and of the Committee on Adequacy and Standards, all in E.C.P.D. During this period these committees have issued several reports which have been widely discussed as guideposts to a new era in engineering education, specifically—"Differentiating Characteristics of an Engineering Curriculum," "Report on Graduate Education in Engineering," and "Adequacy and Standards of Engineering Education."

Dean Hollister's advocacy of a stronger engineering profession through advancement of education has had a companion crusade for some years—that of maintaining an adequate supply of engineering manpower for the technological developments ahead. He is a member of the Manpower Commission of Engineers' Joint Council; of the Committee on Specialized Personnel, Office of Defense Mobilization; and of the Advisory Committee on Engineering Sciences for Selective Service. Recently he has also been appointed to the Advisory Committee for the National Registry of Engineers and Scientists.

He has had long association with ASEE, starting with his first instructorship in 1916, including various committee memberships and chairmanships, and culminating in the presidency of the Society for 1951–52.

Dean Hollister has had many other associations with professional, educational, and governmental organizations, and many continue active. His deep interest is in the advancement of the engineering profession and in stimulation of the educational means toward this end. His efforts as teacher, administrator, and spokesman have focused on this point.

College Notes

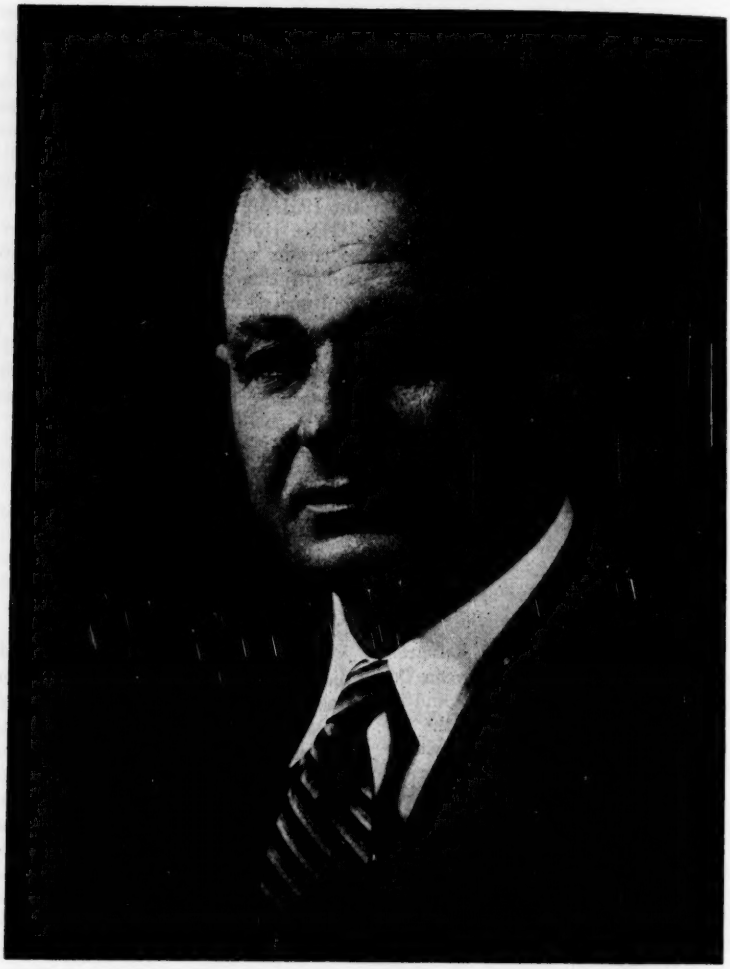
The Division of Cooperative Research, an important top-level link between **Columbia's** new Engineering Center and industry, has been activated with the appointment of Dr. John G. Dean, widely-known research scientist, as Director.

By order of President Truman, Dean S. S. Steinberg, **University of Maryland** College of Engineering, has been awarded a Special Certificate of Merit. The presentation was made by Secretary of Labor Maurice J. Tobin with the citation "for his outstanding contribution as Chairman of the Committee on Education of the President's Conference on Industrial Safety, in grateful appreciation for his performance of duties important to the public interest."

A grant of $150,000 has been made by the Carnegie Corporation of New York to **Case Institute of Technology**, Cleveland, Ohio, to aid in development of an experimental program for liberalizing engineering education which was begun at Case three years ago. The grant will be paid in five equal annual installments beginning this year, said Dr. Elmer Hutchisson, acting president of Case, in making the announcement.

W. J. Cope has been appointed Chairman of the Department of Mechanical Engineering at **Swarthmore College**. Dr. Cope comes to Swarthmore from the **University of Utah** where he has served for the past several years.

George Westinghouse Award—1952—
Gordon S. Brown



To GORDON STANLEY BROWN *for his invaluable work in the development of the science of automatic controls; for his books, technical papers and participation, nationally and internationally, in scientific conferences for the dissemination of technical information in a new field; for his effective contribution to undergraduate education, graduate education and research; for his inspiring guidance in the thinking and outlook of students; and for his influence on his fellow workers, we award this the 7th George Westinghouse Award.*

DR. GORDON S. BROWN, born in Australia in 1907 and naturalized as a U. S. citizen in 1939, was educated at Melbourne (Australia) Technical High School and M.I.T., receiving from the latter institution the Bachelor of Science degree in 1931, the Master's degree in 1934, and the Doctorate in 1938.

Internationally known for his contributions in the field of servomechanisms, he has risen on the M.I.T. staff through the positions of Research Assistant in 1931, Assistant Professor in 1939, Associate Professor in 1941, and Professor of Electrical Engineering in 1946. Appointed Associate Head of the Electrical Engineering Department in 1950, he now serves as Chairman of the Faculty and as a member of the Institute's Academic Council. His latest recognition as an engineering educator was his selection as Head of the Electrical Engineering Department at M.I.T. to replace Dr. Harold L. Hazen, who was promoted to Dean of the Graduate School.

He stands out as a pioneer and leader of current progress in engineering education. He has, to a most extraordinary degree, the faculty of "getting under the skin" of even the most retiring student. His style is completely that of the shirt-sleeves-rolled-up, personal participant in whatever is going on. This means that his influence is direct and personal. The full force of Brown in teaching becomes clear only when one combines his internationally recognized professional stature with his deep interest in students, with his uncanny personal ability to make intimate and forceful intellectual contact with them, and with his consequent ability to inspire them with his dynamic enthusiasm and breadth of outlook.

Few students can be members of his class without responding actively to the challenge he puts forth. His power lies not so much in refinement of technique or nicety and elegance of exposition, but rather in the vigor, perspective, range, and interest of illustrative example, and in his insistence upon getting to the heart of a problem. As an Honors Group Counsellor early in his career, Brown faced one of the most difficult tasks that an undergraduate teacher can encounter. Such a challenge found Brown at his best, and his performance as Honors Group Counsellor was outstanding.

At the opening of World War II, M.I.T. had the only university servomechanisms laboratory in the country. Laboratory Director Brown and his colleagues (many of whom were graduate students) at once undertook a program of research for the armed services that contributed notably to successful prosecution of the war. Since the war the laboratory has been engaged in research of important industrial significance. As director, Dr. Brown has developed a significant blending of fundamental research, professional engineering, and engineering education to the great strengthening of each. His activity has a strong motivating influence on both undergraduate and graduate students.

In 1948 Brown, with one of his students, Professor Donald P. Campbell, wrote a book entitled "Principles of Servomechanisms," which already has won a world-wide reputation.

As an example of his international standing, Dr. Brown was invited to give the opening address to the 1951 Conference on Automatic Control in Cranfield, England. His Servomechanisms Laboratory at M.I.T. has pioneered the development of education in this field and attracts many visitors and students from all over the world.

Errata

In the June issue of the *Journal of Engineering Education* Dr. Wada's name was incorrectly given as "Hiroshi" rather than "Koroku" in the article "The 1951 ASEE Engineering Education Mission to Japan" by Harold L. Hazen.

Secretary's Report
1951-52

This year the ASEE has completed a major project, which stands as a milestone in the accomplishments of the Society, while significant progress has been made on several other projects which are still on the road to completion. Several new projects have been launched during the year. It is the hope of the General Council and the Executive Board that these projects will be carried forth with the same vigor, inspiration, and discriminating judgment which has marked the significant contributions of the past, and that in time, they too will take their place among the clearly defined contributions to the advancement of engineering education.

Although these major projects are the focal point of effort and attention of the Society, they constitute a small portion of the total contribution of the Society to engineering education. Probably the greatest contribution of the Society is in its functioning as a national forum for the interchange of ideas and the unification of efforts of teachers and college administrators representing the many diverse fields bearing upon engineering education. Here, every conceivable phase of engineering education is subject to critical and constructive analysis and out of the cauldron of activity inevitably comes a clearer definition of the major issues and a logical and orderly approach to the solution of the problems. The vigorous activities of the members making up the Councils, Committees, Divisions, Sections, and Branches in this Society are the sources of its great strength and the hope for its future.

Committee on Improvement of Teaching

The report of the Committee on Improvement of Teaching, under the chairmanship of Dr. L. E. Grinter, brings to a close one of the major projects of the Society during the past three years. This comprehensive report presents a critical analysis of teaching objectives and methods. It places great stress upon the need for more successful teaching methods which will develop the student's latent abilities to do resourceful and creative thinking. It emphasizes the need for continued experimentation in educational methods toward the end of preparing the students to meet new situations with skill, resourcefulness, and leadership. It strongly emphasizes the desirability of teaching from basic laws and fundamental principles so that the students will gain a clear understanding of the scientific foundations underlying engineering. Copies of this report are available in any quantity from the headquarters office.

The Year of Evaluation

The rapidly advancing pattern of science and technology is confronting engineering education with numerous problems of broad scope and profound importance. The extension of knowledge of scientific fundamentals has opened doors to vast new areas of engineering endeavor and has greatly strengthened the foundation underlying many of our existing engineering fields. The question is constantly being raised as to whether or not our engineering curricula have sufficient depth and breadth of scientific foundation to enable the engineers of tomorrow to translate new scientific advances rapidly into engineering practice.

The Executive Board and General Council of the ASEE have given this matter careful consideration and have voted to undertake a critical analysis of engineer-

ing education with a view to clarifying the professional objectives and arriving at a clearer definition of the kind of engineering education which is necessary to assure maximum rate of progress of the engineering profession of the future.

A Committee on Evaluation of Engineering Education, under the chairmanship of Dr. L. E. Grinter, has been appointed to serve as a coordinating group for this study. It has been recommended that sub-committees be organized in the Divisions of the Society and in engineering colleges throughout the country and that these sub-committees study the foregoing and other problems related to engineering education and submit reports to the central committee. The recommendations of these sub-committees will then be consolidated into a unified report.

Cooperation between Engineering Colleges and Secondary Schools

A second project of the year has dealt with the development of closer working relationships between engineering colleges and secondary schools, with a view toward improving the educational background of students and also of developing closer liaison in matters relating to student guidance. This has arisen out of numerous expressions of concern among college educators over the inadequate preparation of students, particularly in the curricular areas of mathematics and the sciences. In the belief that this situation can be improved by concerted action, the Executive Board and General Council of the ASEE voted to develop this as a major project of the Society.

Significant progress has been made during the past year by the Sections of the Society, many of which have held conferences in which engineering educators and high school teachers and principals have presented their views. A number of engineering colleges are developing constructive, forward-looking programs in their local areas, in order to develop a common-ground interest between engineering educators and high school teachers. Several colleges are undertaking to offer specific courses for secondary school teachers in order to help them to understand more clearly the interrelationships between mathematics, physics, and engineering education.

The Fall meeting of the ECAC in Houston, Texas was devoted entirely to a program of cooperation between engineering colleges and secondary schools. Several excellent papers on the subject were also included in a conference of the Division of Relations with Industry in January. The Society has assembled these papers in a booklet "Developing Cooperative Relationships Between Engineering Colleges and Secondary Schools" which has been sent to the deans of engineering colleges and the Section chairmen.

Participation of Younger Faculty Members in ASEE Activities

One of the most promising developments during the past year has been that of lending increased emphasis to the stimulation of activities of younger faculty members in meetings and affairs of the Society. The younger faculty members have much to contribute to the constructive work of the Society, since they often have a vigorous, forward-looking approach to the problems of education. It is believed that they are a potent force which should be tapped and woven into the Society activities. Active participation in the affairs of the Society would enable the younger faculty members to gain a broader persepective of engineering education and it would help them to acquire effective teaching methods at a time when these tend to become crystalized.

Many of the Sections of the Society have given this problem serious consideration and are encouraging younger faculty members to take over responsible planning of part of the Section activities. The Executive Board is recommending that a national paper contest be undertaken by the Sections of the Society in order to stimulate participation of younger faculty members in the programs of the Sections. The Section winners of the paper contest

would then compete nationally for awards of the ASEE.

Teaching Aids Committee

The Committee on Teaching Aids has a number of reviewing committees actively engaged in reviewing and evaluating teaching aids for possible use in engineering instruction. A bulletin, listing acceptable teaching aids, giving details as to size, curricular use, availability, etc., will be published by the Committee. It is anticipated that publication will be completed next year. The Committee has carried on a highly successful fund-raising program and has obtained over $8500 in industrial contributions to carry forward the project.

Unity of the Profession

The recommendations of the Exploratory Group of the EJC on Unity of the Profession have been submitted to the participating societies for official action. These recommendations, centered around Plan A, provide for an enlarged EJC to include those qualified engineering organizations which have approved the plan. Assuming that a sufficient number of engineering societies approve the plan, a constitutional convention will be held to prepare a constitution for the new Unity organization. Although EJC is basically a council type of organization, it is still possible for the constitutional convention to revise the basic plan to provide for individual membership.

Mid-Year Meetings of Divisions of the ASEE

The Division of Relations with Industry held its mid-year meeting at MIT in January on the theme "The Student as an Individual." This meeting was attended by over 300 industrial representatives and faculty members.

The Engineering Drawing Division held its customary mid-year meeting in New York in January. The program included demonstrations of descriptive geometry as applied to ship building, photographic and color photographic processes, and a trip to Columbia University's cyclotron.

The Cooperative Engineering Division held its mid-year meeting at Northwestern University, the program consisting of a workshop discussion of the problems and policies of cooperative engineering education.

Publications of Divisions of the Society

In the past, perhaps all too little recognition has been given to some of the excellent work of the Divisions of the Society in the form of quarterly or semi-annual publications which contain technical papers in specific curricular areas. The Engineering Drawing Division was the first Division of the ASEE to establish its own bulletin. This has served a very constructive purpose in disseminating technical information on engineering drawing. The Civil Engineering Division for a number of years has published a quarterly bulletin, which contains technical papers in the diverse fields of civil engineering. The Machine Design bulletin, edited by the Machine Design Committee of the Mechanical Engineering Division is another outstanding example of a publication which is getting outstanding technical papers before the members of the Division. Each year, the Chemical Engineering Division prepares its Chemical Engineering Abstracts, representing papers presented at the Annual Meeting. The Southeast Section of the Society publishes its papers each year in a mimeographed volume, which is distributed to the members.

These bulletins are edited entirely by members of the Divisions and the cost of publication is offset either by including advertising of textbook publishers, or from the sale of the journals to the members.

ASEE Sponsored Summer Schools

This year, the ASEE sponsored four summer schools. The English Division, Electrical Engineering Division, and Civil Engineering Division (Sanitary Engineer-

ing) are all holding summer schools prior to the Annual Meeting at Dartmouth College. The ASEE also endorsed the Third National Surveying Teachers Conference, which was sponsored by the Civil Engineering Division and the University of Illinois. A unique summer school, sponsored by the ASEE, has been worked out jointly by the Committee on Improvement of Teaching and the General Electric Company. This program emphasizes teaching methods which develop originality and creative approaches in engineering.

Future Annual Meetings

The Annual Meetings for the next two years have been scheduled. The meeting in 1953 will be at the University of Florida and will be held on June 22–26. The University of Illinois will have the 1954 Annual Meeting.

New Committees

During the year, a Committee on Textile Engineering has been appointed, at the request of a number of faculty members and administrators in this field.

A Committee on Public Relations was appointed, under the chairmanship of Professor Schmelzer, during the year.

Associate Institutional Memberships

The industrial members of the ASEE have been a source of great vitality and strength in the operations of the Society. The Executive Board of the Society believes that increased participation of companies which have extensive engineering operations will inevitably accrue to the benefit of both industry and the educators. Consequently, a committee has been appointed under the chairmanship of Jesse McKeon to solicit Associate Institutional Memberships in the Society. This Committee is to be highly commended for its work, having obtained twenty-four new Associate Institutional Memberships during the past year alone.

Advertising in the Journal

The headquarters office of the Society is endeavoring to obtain new advertisers for the *Journal of Engineering Education* in order to expand this source of revenue. Preliminary results show that it should be possible to increase the advertising revenue significantly in the next few years. This will help to offset rising costs of operation, incurred by the continued expansion of Society activities.

Membership

Early in the year, a letter was sent to the deans of engineering colleges throughout the country, asking them to supply names of persons outside of the strictly engineering faculties who are actively teaching courses to engineering students. These included faculty members in mathematics, physics, and the social sciences and humanities. This request met with enthusiastic approval of the deans and over 500 letters of invitation to join were sent to faculty members proposed by the deans. This will result in a substantial strengthening of these Divisions of the Society. The total number of new members added this year is 520.

Participation in Activities of Other Societies

The Society has continued its active participation in many engineering and educational societies, including the Engineers' Council for Professional Development, the American Council on Education, the American Association for the Advancement of Science, the Educational Testing Service, the National Research Council, and the American Standards Association. Society representatives have been appointed to each of these organizations and in many cases the Society, through its representative, has contributed significantly to the work of the organizations.

Respectfully submitted,

A. B. BRONWELL
Secretary

Minutes of Executive Board Meeting

A meeting of the Executive Board of the American Society for Engineering Education was held on Monday, June 23, 1952, at Dartmouth College, Hanover, New Hampshire. Those present were: S. C. Hollister, *President,* M. M. Boring, L. E. Grinter, J. H. Lampe, G. A. Rosselot, *Vice-Presidents,* C. L. Skelley, *Treasurer,* A. B. Bronwell, *Secretary,* C. E. Watson, *Assistant Secretary,* and B. Bowen.

Reports of Officers

Written reports of the Vice-Presidents and Secretary were discussed. A resume of these reports is given in the Minutes of the General Council meeting of June 23, 1952.

Treasurer's Report

The Treasurer presented the tentative annual audit to the Executive Board. The final audit (prepared subsequent to the Annual Meeting) shows a net excess of income over expense of $4268. The individual dues increased approximately $600 over the preceding year and the institutional dues increased approximately $1500. Advertising revenue was up approximately $1000. The expenses were in line with those of the preceding year, except for ECRC expense, which was considerably lower owing to a reduction in the ECRC publication program.

The income from sale of ECRC publications amounted to $3484.85. The Board discussed the transfer of funds to the ECRC reserve. According to a previous Executive Board ruling, the transfer to the ECRC reserve should include the unused budget of ECRC in addition to the income from sale of ECRC publications. The advisability of establishing a practice of transferring unused portions of the budget to a reserve for any particular group within the Society was questioned. However, it was recognized that the ECRC expenses fluctuate sharply, owing to the publication schedule of the particular year and that failure to establish an adequate reserve might subject the Society to a substantial deficit in a year when ECRC expenses are abnormally high. Accordingly, the Executive Board voted to transfer the unused portion of ECRC budget in addition to the ECRC income to the ECRC reserve for use in future years, with the understanding that this was not to be regarded as a precedent for future years.

The Executive Board also considered the general problem of supervision of expenditures of various groups within the Society. It was pointed out that the Divisions and Committees of the Society prepare a budget in May of each year for their anticipated expenditures during the following fiscal year. Aside from this budget, the Society headquarters does not at present maintain control over financial commitments of the Councils, Divisions and Committees, other than approval within the stipulated budget limits after the expenses have been incurred. In order to maintain closer supervision over financial commitments, the Executive Board voted that any item of expense exceeding $200 should first be approved by the Secretary's Office before financial commitment is made.

The budget for 1952–53 was approved, pending certain adjustments in income and increased secretarial staff salaries.

Report of Committee on General Council Activities

The Board discussed the report submitted by a Committee on General Council Activities, under the chairmanship of

Dean Barlow. This Committee was appointed to suggest means of enlarging the participation of the General Council in Society affairs. The report is summarized in the Minutes of the General Council meeting.

Society Organization

Consideration was given by the Executive Board to the problem of integrating the activities of the various Divisions, Sections, and Committees of the Society into an organic unit so as to improve the flow of ideas upward into the General Council and Executive Board and also so as to stimulate these groups to work on some of the overall problems of the Society. It was pointed out that the various Divisions, Committees, and Sections each operate in specialized areas and, although they may serve effectively in handling the problems in these restricted areas, they do not in general participate in some of the broader Society problems and policy matters.

Much of the basic policy of the Society originates in the Executive Board and flows downward into the General Council, where it is activated by the appointment of special committees. There is need for reversing this flow so that ideas originating in the Divisions and Sections will be encouraged to flow upward into the General Council where they can be activated. The Board recommended to the General Council that an ad hoc committee be appointed to study the Society organization and functioning and to make recommendations for improvements which will integrate the Society activities into a unified program.

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A meeting of new and old officers of the Executive Board of the American Society for Engineering Education was held on Wednesday, June 25, 1952, at Dartmouth College, Hanover, New Hampshire. Those present were: S. C. Hollister, *President,* M. M. Boring, L. E. Grinter, J. H. Lampe, G. A. Rosselot, C. L. Skelley, E. A. Walker, W. C. White, W. R. Woolrich, A. B. Bronwell, C. E. Watson, and B. Bowen.

Evaluation of Engineering Education

The plans for the program of the Committee on Evaluation of Engineering Education were discussed. The first meeting of the Committee was scheduled for the last day of the ASEE Annual Meeting at Dartmouth College. It was anticipated that the general problems and the method of attack would be formulated at that time and that the ASEE committee would request the deans of engineering colleges to appoint institutional committees to cooperate in this broad program.

Participation of Associate Institutional Members in Society Activities

The Board gave consideration to ways of developing a closer functional relationship between the Associate Institutional members and the activities of the Society as a whole. It was pointed out that the company representatives can play an active and influential role in the advancement of engineering education if they are acquainted with the objectives and philosophy of engineering education and if proper channels are provided for active participation in the Society. The highly successful activities of the Division of Relations with Industry have given impetus to the role which industry can take in working with engineering colleges in all phases of engineering education. Some concern was expressed over the possibility that industrial members of the Society might feel that they are superfluous in Society activities. This would deny the Society of a powerful and constructive influence which could render a great service to the Society. Accordingly, the Board recommended to the Council that an ad hoc committee consisting of Vice-President Boring and Mr. McKeon be appointed to study means of implementing increased participation of Associate members in activities of the Society.

Future Annual Meetings

President Hollister explained to the Board that subsequent to the time it re-

ceived the invitation from Cornell University, an invitation had been received from Pennsylvania State College inviting the Society to hold its 1955 Annual Meeting at State College, Pennsylvania. This would commemorate the 75th year of Pennsylvania State College. In view of the fact that Cornell had been host to the Society for three Annual Meetings and Pennsylvania State College had been host only once, and in view of the importance of the occasion, Dean Hollister stated that he was withdrawing the request for the Annual Meeting at Cornell University. No action was taken.

Bank Resolution

The Executive Board voted to authorize the President or Treasurer to co-sign checks with either the Secretary or Assistant Secretary, in accordance with previous practice.

Application of Ohio University for Active Institutional Membership

The application of Ohio University for Active Institutional Membership was presented. It was voted Active Institutional Membership by the Board.

Representative to UPADI

The Board voted to appoint Deans Steinberg and Lassalle as the official ASEE representatives to the meeting of the Pan American Congress UPADI to be held in New Orleans in August.

Insurance Plan

A plan which would provide for group disability insurance for members of the Society was briefly considered by the Board. The proposal was presented to Mr. Boring with a request that it be considered by some of the actuarial people in General Electric Company.

Expression of Appreciation from the President

The President of the Society expressed to the members of the Board his appreciation for the privilege of working with the Board on behalf of the Society during the past year, and expressed his grateful appreciation for the loyal cooperation and effective assistance which he had received.

Other Items of Business

Other items considered by the Executive Board on which actions are summarized in the Minutes of the General Council Meeting are:

1. Advertisements of teaching positions in Journal;
2. Unity of the Profession;
3. Continuation of program of cooperation between engineering colleges and secondary schools;
4. Participation of younger faculty members in activities of the Society;
5. Expansion of the Secretarial staff;
6. Society emblem;
7. Plans for Joint ASEE–ECPD meetings in Chicago.

Respectfully submitted,
ARTHUR B. BRONWELL
Secretary

College Notes

B. Richard Teare, Jr. has been appointed Associate Dean of the **Carnegie Institute of Technology** College of Engineering and Science. Dr. Teare will work closely with Dean Webster N. Jones in the general administration and policy planning of the College of Engineering and Science, including financial and educational development. The new Associate Dean is also Dean of Graduate Studies and Buhl Professor of Electrical Engineering.

Minutes of General Council Meeting

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Reports of Officers

Written reports of the Vice-Presidents, Treasurer, and Secretary were presented, including a tentative annual audit and a budget for 1952–53.

Unity of the Profession

Dean Saville presented a recommendation that the ASEE formally approve the final plan proposed by the EJC's Exploratory Committee on Unity of the Profession. The Exploratory Committee recommended that the most feasible way to achieve unity was to adopt essentially Plan A, which would provide for a modification of the EJC structure to serve as a Unity organization. Dean Saville stated that the Executive Board of ASEE had recommended to the Council the endorsement of this plan and that in his opinion this would be the last opportunity for a number of years to come to form such a Unity organization. If it failed, there would probably be considerable adversity to any future attempts at the formation of such an organization. If the proposed plan is approved, a Constitutional Convention will be called to alter the EJC Constitution. Only those organizations signifying their approval would participate in drafting the Constitution.

It was voted that the ASEE signify to EJC its willingness to become a member of the EJC under approximately the provisions of Plan A if the invitation is extended.

Committee on Improvement of Teaching

Vice-President Grinter briefly reviewed the plan of operation of the Committee on Improvement of Teaching and the end results. He stated that approximately 1000 to 1500 people had been engaged in activities of this Committee on the institutional and national level. He recommended that the Committee be dissolved and that the activities be transferred on a permanent basis to the Division of Educational Methods.

Cooperation Between Engineering Colleges and Secondary Schools

Vice-President Boring reported on the work of the Sections in developing the program of cooperation between engineering colleges and secondary schools. This has been a joint undertaking of the Sections and the ECAC's Committee on Secondary Schools. He stated that a number of Sections have developed conferences with high school teachers and principals during the past year and that the results point to considerable potentiality for future development.

He also mentioned that the Engineering Manpower Commission of EJC has presented the story of the critical shortage of engineering manpower to 28,000 high school students throughout the country. Likewise, the Edison Foundation and the National Science Teacher's Association, which were established to promote interest in science and increase the flow of students into the scientific professions, have held conferences of officials in government, together with teachers in the engineering and science fields. These programs collectively have reversed the downward trend of engineering enrollments and produced a 15% increase in freshman engineering enrollment as compared with a 12% decline in all college enrollment.

Participation of Younger Faculty Members in ASEE Activities

The Secretary reported that the Executive Board has considered several programs for stimulating the activity of younger faculty members in the affairs of the Society. The Board recommended to the Council that a paper contest be inaugurated, to be developed by the Sections of the Society, as a means of enlisting the active participation of younger faculty members. The Board believes that as a consequence of an appeal through the President's Newsletter, most of the Sections of the Society are giving active consideration to developing conferences and programs where the younger faculty members manage the affairs and take the leading role. This program will have to develop primarily at the Section level, since for financial reasons, not many of the younger faculty members are able to attend the Annual Meetings of the Society.

The General Council voted to inaugurate a paper contest for younger faculty members on a broad subject to be announced by the President of the ASEE. Each Section would provide its own rules and would select the winning papers. These would be presented at the next Annual Meeting in June 1953. Awards of $200 and $100 each would be given for the two best papers presented by young faculty members.

A discussion of the age limit was not definitely settled, although it was tentatively agreed that the upper limits should be either 35 or 36 years of age.

Report of the Engineering Manpower Commission

Dr. Armsby reported that the Engineering Manpower Commission has presented testimony before Congress in connection with the Reserve Bill, in favor of placing the calling of reservists under a civilian agency rather than under the Department of Defense. It was believed that a civilian agency would be more discriminating as to the needs of the country for scientists and engineers than the military agencies.

Coordinating Committee on Relations with the Federal Government

Dean Saville reported on the work of the Coordinating Committee on Relations with the Federal Government. He urged that a closer liaison be established between the ASEE's Manpower Committee and the Engineering Manpower Commission of EJC, since no members of the ASEE committee have been on the Manpower Commisssion. He stated that the Manpower Committee, under the chairmanship of George Lobingier, has proposed that attention be given to immediate and satisfactory placement of engineering graduates who returning to civilian life after having completed their service duty.

Upon motion from Dean Saville, the Council voted to request the Executive Board to instruct Society representatives on the Engineering Manpower Commission of EJC to urge organization of a program in cooperation with the military services, industry, and the engineering colleges, to provide an adequate means for channelling engineers leaving military services into professional engineering positions.

Dean Saville also commented on the need for closer correlation of the ROTC policies of the three military services, par-

ticularly those of the Air Force, which is instituting a new ROTC program.

On resolution from Dean Saville, the Council voted to request the Executive Board to instruct the Society representatives on the American Council on Education to initiate appropriate action looking toward a better coordination of ROTC policies of the three military services and the implementation of joint policies looking toward improvements in existing practices relating to curricula, credits, teaching staff, and other elements of the ROTC programs.

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A meeting of old and new members of the General Council was held at Dartmouth College, Hanover, New Hampshire on Friday morning, June 27, 1952. Those present included: S. C. Hollister, *President;* M. M. Boring, L. E. Grinter, J. H. Lampe, G. A. Rosselot, *Vice-Presidents;* C. L. Skelley, *Treasurer;* A. B. Bronwell, *Secretary;* C. E. Watson, *Assistant Secretary;* Wm. Allan, H. H. Armsby, H. J. Barre, H. W. Barlow, H. R. Beatty, H. A. Bolz, M. P. Capp, W. H. Carson, D. S. Clark, F. M. Dawson, W. W. Dornberger (substituting for S. A. Smith), C. J. Freund, W. P. Godfrey, D. M. Griffith, C. O. Harris, D. Hunt, E. Hutchisson, H. Kuenzel, L. Jones, E. Laitala, E. J. Lindahl, J. C. McKeon, F. H. Miller, L. G. Miller, T. H. Morgan, C. Muhlenbruch, E. F. Obert, G. K. Palsgrove, O. H. Polk (substituting for R. S. Glasgow), J. C. Reed, N. F. Rode, J. H. Rushton, H. C. Spencer, L. O. Stewart, E. A. Walker, K. O. Werwath, C. L. Wilson, W. C. White, B. L. Wellman, K. Wendt, H. H. Wheaton, D. G. Wilson, S. E. Winston, W. R. Woolrich.

Fall Meetings of the ASEE–ECPD

The Secretary announced the plans for the joint ASEE–ECPD meetings to be held in conjunction with the Centennial of Engineering in Chicago on September 5–6. The ECRC conference on the theme "The Engineer is a Scientist" is scheduled for the morning of September 5, and the ECAC conference in the afternoon will deal with "What Are Contemporary Demands on Engineering Education." The ASEE and the ECPD will hold joint luncheons on Friday and Saturday and a dinner on Friday evening.

Technical Assistance Program

The Secretary reported on the January meeting of the Council on Economic and Social Development held in Washington. The purpose of the Council was to acquaint officers of learned societies and administrative officers of educational institutions with some of the objectives and problems of the government's technical assistance program. He stated that technical education at all levels is regarded as one of the important phases of the technical assistance program and that the ASEE could make a substantial contribution in helping to develop satisfactory technical educational programs in foreign countries.

Committee on International Relations

Dean Woolrich reported for the Committee on International Relations that a proposal had come from the State Department requesting assistance of the ASEE in handling policy matters relating to the placement of international exchange students in American industries for experience. The proposal came through the National Science Foundation and referred specifically to students from Great Britain. The students would pay their transportation, but attempts would be made to arrange for jobs in American industries for experience. In return, a number of American students would be permitted to visit Great Britain under a similar educational exchange program.

Expansion of the Office of the Secretary

The President announced the appointment of Professor C. E. Watson as Assistant Secretary on a part-time basis. Professor Watson has been handling editorial work for the Society and will also handle the solicitation of advertising for the Journal of Engineering Education.

Treasurer's Report

The report of the Treasurer relating to the annual audit is summarized in the Minutes of the Executive Board meeting. Subsequently, the final audit as of June 30, 1952 showed a net excess of income over expense of $4268 for the past year. This occurred after transferring $6004.69 to the ECRC reserve. The Executive Board approved the transfer, since the ECRC expenses fluctuate according to their publication schedule. The ECRC had no publications during the past year, but contemplated rather extensive publication schedule in future years. This transfer to the ECRC reserve enables the Research Council to smooth out its financial operations, so as to avoid a heavy drain on the Society finances in any one year.

The proposed budget for the next fiscal year was presented to the Council, and approved subject to certain changes.

The President stated that it was the policy of the Executive Board to provide for increased assistance in the Secretary's office so as to free a portion of the Secretary's time for important liaison work with other organizations and for furthering the development of Society projects. He stated that this would assure a more stable organization in the future. He expressed the opinion that the Society's affairs were in sound condition.

Report of the Vice-Presidents

Vice-President Grinter presented the written report on activities of the Divisions and Committees. He briefly discussed the Society organization and emphasized the need for bringing the Divisions and Committees into the forefront of the Society's activities in order to provide stimulus for continued progress. He stated that it was his hope that the Divisions can be brought into active participation in the study on Evaluation of Engineering Education which will be taking shape during the coming year. Dr. Grinter also announced that the Graduate Division had prepared a revision of the Manual of Graduate Study in engineering and that this would be completed in the near future.

Vice-President Boring reported on activities of the Sections and Branches of the Society. He recommended that a study be made of some of the geographical areas of the Sections, since it seemed that excessive travel distances discouraged attendance at Section meetings, particularly among the younger faculty members who could profit most by such participation. A general discussion from the Council members followed, in which it was pointed out that it might be well for the Sections themselves to propose a more effective plan of Section organization. The suggestion was made by Dean Wilson, Dr. Armsby, and Professor Pumphrey that a committee of the ASEE be appointed to study the problem in cooperation with the Section officers. No action was taken on this recommendation. It was also suggested that the present Sections had developed a substantial community of interest and pride in their regional activities. It might therefore be advisable to consider maintaining present Section autonomy with meetings once a year, but encourage educational institutions within a given local geographical area to develop ASEE programs within the framework of the present Section organization.

Vice-President Lampe presented a written report covering the work of the ECAC and its five committees. He reported on the success of the Houston meetings, centered on relations between engineering colleges and secondary schools in matters relating to the improvement of student preparation, guidance, and counseling. He stated that the ECAC was studying the transfer of credits from junior colleges to engineering schools. He reported on the session for Institutional representatives which dealt with administrative problems arising out of military affairs, salary trends, teaching loads, ROTC and NROTC programs, the satellite system which is developing between engineering colleges and liberal arts colleges, and the expansion of research activities. The Selection and Guidance Committee of the ECAC has as-

sisted the Educational Testing Service in the development of tests for the selection and guidance of students. Vice-President Lampe stated that a committee of the ECAC was currently studying teaching loads and salaries. He also pointed out that the ECAC has planned a conference with the Air Force ROTC officials to discuss curricular plans for the new Air Force ROTC program.

Vice-President Rosselot, reporting on the activities of the ECRC, stated that three new institutional members, St. Louis University, Lowell Institute, and Tulane University, were added to the ECRC during the past year. In reporting on the work of the Committee on Contract Relationships with the Government, he stated that considerable progress had been made toward getting recognition by government officials of the need for unified treatment of research contracts with engineering colleges. He reported that the ECRC general session program at the Annual Meeting dealt with the currently important problem of the impact of government operated and government sponsored laboratories on teaching and research.

Society Organization

The Report of the Committee on Activities of the General Council was presented to the Council. This report recommended that the Society should:

(1) Inaugurate at the Annual Meeting a general business meeting to present resolutions from Divisions, Committees, and Sections for consideration and discussion by the Society membership at large. The resolutions would be submitted to a Resolutions Committee for clarification and final drafting to avoid ambiguities. These resolutions, together with recommendations from the floor, would provide machinery for the flow of ideas from Sections, Divisions, Committees, and the general membership to the Council.

(2) Clarify the duties and responsibilities of members of the General Council.

(3) Present Governmental requests for engineering educators for special services to the Section representatives of the Council for recommendation in order to provide adequate geographical coverage.

(4) Improve the liaison between Council members and their Divisions and Sections by requiring that each Council member report at least once a year to his Section or Division on the activities of the Society and the Council; also that the Divisions and Sections be urged to use the Council member more fully by transmitting to the Council resolutions or proposals of the Section or Division.

(5) Establish a procedure whereby the Journal could serve as a clearing house to facilitate the exchange of graduate students with faculty standing.

(6) Establish in the Journal a section devoted to advertisement of teaching positions open.

(7) Recommend to the Sections and Divisions that only those members be considered for representation on the Council who will be able to attend Council meetings. It was suggested that either the current Section or Division chairmen or the retiring chairmen be considered for representation of the Division or Section on the Council

President Hollister stated that the Executive Board had given consideration to this problem of improving the Society organization. He pointed out that a number of Committees of the Society operate in the same areas as Divisions and that Sections of the Society have programs which cut across all of the Divisions and Committees. He stated that the Executive Board had authorized appointment of a Committee on the Improvement of Society Function with broader responsibilities than the Committee on General Council activities. This Committee will be composed of seven members under the chairmanship of B. R. Teare.

The Barlow report was accepted and items (3), (5), and (6) were referred to the Executive Board for action. The balance of the report was referred to the new Committee on Improvement of Society Function.

Teaching Position Advertisements in the Journal

One of the recommendations of the Barlow Committee report was that the Journal should carry advertisements of teaching positions. This was discussed at length by the Council. It was pointed out that this might have the immediate effect of placing lower salary bracket schools at a disadvantage. However, the long-range effect would be to tend to raise salaries in these schools. The Secretary reported that, with its present office staff, the Society could not serve as a clearing house and maintain personnel records. However, the Society can place blind ads in the Journal and relay replies to the particular institutions. It was the concensus of opinion that if ads were placed in the Journal they should be restricted to positions available in engineering colleges. The matter was referred to the Executive Board for further study.

Summer Schools

Mr. McEachron reported on the seminar of teaching methods which the General Electric Company sponsored during the week prior to the Annual Meeting. This was a joint undertaking by the Committee on Improvement of Teaching and the General Electric Company and was devoted to presenting teaching methods which develop originality and creative approaches in engineering. The Secretary also announced that ASEE summer schools in Electrical Engineering and Civil Engineering (Sanitary) had been held prior to the ASEE meeting at Dartmouth.

International Management Conference

Mr. McEachron reported that the International Management Conference would hold its next meeting at Delft and recommended that the Society appoint an official ASEE representative. The Council voted to authorize the Executive Board to make an appointment.

Relations with Industry Division Meeting with AAAS

Mr. McEachron reported that the Division on Relations with Industry had been approached by the AAAS to hold a joint meeting in St. Louis at the time of the Annual Meeting of the AAAS. The Council voted to approve such a meeting, subject to the wishes of the Division on Relations with Industry.

Associate Institutional Membership

Mr. McKeon presented a progress report on the Associate Institutional Membership drive. He reported that a pilot operation involving fifty companies had yielded twenty-four memberships and six additional commitments. He expressed the belief that a substantial number of companies will probably be interested in taking out institutional membership in the Society.

President Hollister emphasized the need for bringing industry and engineering education into a closer mutual relationship as respects the objectives of engineering education and also to provide a constructive program whereby Associate Institutional members will take a responsible role in the activities of the Society. He emphasized the need for close coordinated action on the part of teachers and industry in order to develop a sound approach to the advancement of engineering education. Dean Saville reinforced this point of view by stating that industrial men had proven unsuccessful on ECPD accreditation committees because they were not acquainted with the objectives and basic philosophy of engineering education and he hoped that by bringing engineers into more active participation in the Society, this would prepare them for responsibilities in accreditation work.

Reports of Committees

Constitution and By-Laws. Dr. Armsby presented the resolution of the Committee on Constitution and By-Laws to the effect that the Committee did not believe that the objectives of the Society can be improved

by hasty revision of the constitution, but rather that the problem should be studied carefully and that constitutional revision should be presented only when there is clear evidence of need. The Council voted to approve the resolution.

The Atomic Engineering Education Committee. Dr. Armsby stated that the Atomic Engineering Education Committee had been appointed two years previously and that the five regional committees had functioned very satisfactorily in developing regional programs on atomic engineering education. It was recommended that the committee be continued, but with a rotation of committee membership.

Teaching Aids Committee. Professor Muhlenbruch announced that the Committee on Teaching Aids is actively evaluating aids for use in engineering instruction and now needs the concerted assistance of faculty members throughout the country in supplying ideas of teaching aids which may be suitable for teaching purposes. He emphasized that the only way in which the committee can learn about available teaching aids is to have them brought to their attention by various faculty members.

Emblem for the Society

The emblem recommended by the Executive Board for the flag to be flown at the Centennial of Engineering and for tentative adoption of the Society was discussed and approved. This had been prepared by Professor Blakeslee at the University of Detroit. It was understood that this constituted tentative approval and that the General Council could revise this emblem in the future if it deemed such action desirable.

Resolutions of the Technical Institute Division

President Werwath read two resolutions of the Technical Institute Division. The first emphasized the critical shortage of engineers and technicians and the general lack of understanding on the part of the public and educators concerning the place of the technician, owing to inconsistent terminology. It therefore recommended that, in the interest of clarity and public understanding of the nature of the technical institute training and the place of the technician in industry, members of the ASEE be urged to refer to graduates of technical institutes as *engineering technicians.* It also advocated an *associate degree* as an appropriate title of accomplishment to distinguish from the baccalaureate degree granted by engineering colleges. It was recommended that the resolution be referred to a committee of the General Council with the request that a report be prepared to be submitted to the Society as a whole.

The second resolution of the Technical Institute Division proposed that the ASEE recommend to the Department of Defense the establishment in approved technical institutes of a Reserve Technical Training Corps. The Council voted to refer this resolution to the ASEE representatives on the Engineering Manpower Commission of the EJC. Dean Saville further suggested that these two proposals, along with the proposals of the Coordinating Committee on Relations with the Federal Government be referred to the Engineering Manpower Commission and the American Council on Education. The Council approved the motion.

In closing the meeting, President Hollister mentioned the death of three distinguished past presidents, Dugald C. Jackson, Fred E. Turneaure, and Charles E. MacQuigg. The following resolutions extending the sympathy of the Society to the families were voted by the Council. The Council also passed a resolution of greetings to Dean H. P. Hammond, who was unable to attend because of illness.

Tribute to Dugald C. Jackson

At the 60th Annual Meeting of the American Society for Engineering Education held at Dartmouth College in June 1952, the General Council of the American Society for Engineering Education unanimously voted the following tribute to its eminent past president and distinguished educator.

The American Society for Engineering Education desires at this time to express to Mrs. D. C. Jackson and her family its deepest sympathy on the passing of their beloved husband and father, Dugald C. Jackson. Dr. Jackson was held in high esteem by all who were privileged to know him. He was a man of high ideals and great breadth of vision who understood the relation between education, industry, and government. He was a leader in intellectual thought and a vigorous champion of the advancement of the professions of engineering and education. Practically every major engineering society can claim Dugald C. Jackson as a distinguished contributor to their progress, but the American Society for Engineering Education takes pride in claiming him as its distinguished past president and as one of the truly great men who built the Society to its present high stature. Seldom is it given in the lifetime of man the privilege of associating with a man of the vision and ability to translate ideas into action for the progress of humanity which Dr. Jackson possessed. Therefore, in humble tribute, the American Society for Engineering Education wishes to extend its greetings to Mrs. Jackson and to her family, with the clear recognition that the work of Dugald C. Jackson and his influence have created a permanent and growing memorial far beyond the ability to express in words.

Tribute to Charles E. MacQuigg

At the 60th Annual Meeting of the American Society for Engineering Education, held at Dartmouth College in June 1952, the General Council for the American Society for Engineering Education unanimously voted the following tribute to its distinguished past president.

The American Society for Engineering Education wishes to extend to Mrs. Charles E. MacQuigg and her family their deepest sympathy on the passing of their beloved husband and father. To the members of the American Society for Engineering Education and to all who had the privilege of associating with him, Dean MacQuigg was held in high esteem as a great humanitarian and a man of depth of vision and understanding of human problems. He was ever humble and self-effacing but his vision and broad perspective exerted a profound influence throughout the entire educational fraternity, as well as in local, state, and federal governments. His untiring devotion in guiding his own institution, Ohio State University, into a position of leadership among engineering colleges and his active participation throughout many phases of the work of the American Society for Engineering Education, and as its distinguished president in 1947 have earned him the high respect and esteem of engineers and educators throughout the country. His widespread influence in the engineering and educational professions, in the local, state and federal governments, as well as his great humanitarian interests, are an enduring tribute to a truly great man.

Tribute to Frederick Turneaure

At the 60th Annual Meeting of the American Society for Engineering Education held at Dartmouth College in June 1952, the General Council of the American Society for Engineering Education unanimously voted the following tribute to Frederick Turneaure, a distinguished past president of the Society and a great engineering educator.

The American Society for Engineering Education wishes to express to the family of Dean Frederick Turneaure its deepest sympathy on his passing. Dean Turneaure was an eminent engineer and a truly great educator. He was a relentless worker for the advancement of the engineering and educational professions. His depth of in-

sight and broad perspective of the trends of engineering education were clearly evident in his presidential address when he became the distinguished president of the Society for Promotion of Engineering Education. Dean Turneaure was held in high esteem by all who were privileged to associate with him. His untiring work contributed profoundly to the building of this Society to its present high stature. Throughout the educational and engineering professions Dean Turneaure's influence has built an enduring memorial, a tribute to a great man.

Respectfully submitted,
ARTHUR B. BRONWELL,
Secretary

Sections and Branches

The **Ohio Section** held its annual meeting at the Ohio State University on May 3, 1952. The meeting was opened by S. M. Marco. F. W. Heimberger and E. E. Dreese welcomed the members to the campus.

The morning session was devoted to discussions on counselling high school graduates to enter engineering. G. B. Earnest presided. The first speaker was R. D. Landon. He discussed the various information bulletins he has prepared and sent out to high schools in the northern part of Ohio. He then introduced his guest, O. L. Schneyer, who gave a few remarks on "What Colleges Can Do to Help the High Schools." The next speaker was J. G. Odgers, Jr.

The afternoon session started with a report by R. T. Howe on the Objectives of Young Engineering Teachers Committee. E. W. Weaver reported on the activities of this committee at the University of Toledo.

The following slate of officers was nominated and unanimously approved: Chairman, H. K. Justice; Vice-Chairmen, E. O. Scott and N. D. Thomas; Secretary, K. F. Sibila.

H. K. Justice presided at the regular afternoon session which had as its theme, "Counseling Superior Students to Enter Graduate Work." L. G. Mitten and R. J. Anderson were the speakers.

The **National Capital Area Section** of the American Society for Engineering Education held its 1952 Annual Meeting on May 10, 1952 at The George Washington University, Washington, D. C.

The topic for the morning session was "What Can the Secondary Schools Do to Help in the Training of Engineers." Chairman William Oncken, Jr., presented the panel of five speakers whose names are as follows: W. T. Read, Harold A. Haynes, Charles E. Bish, Wilbur Jones, and Marian Magruder.

The afternoon session consisted of discussion on the topic: "Trends in Engineering Education," following a paper by Robert Roy, Assistant Dean of Engineering, The Johns Hopkins University, on the subject "The Hopkins Plan."

The following officers were elected for the year 1952–53: *Chairman:* L. K. Downing. *Vice-Chairman:* C. H. Walther. *Secretary-Treasurer:* Dugald C. Jackson, Jr. *Council Representative:* Two year term: H. H. Armsby.

New Members

AUZENNE, GUSTAV, Chairman and Associate Professor of Business Administration, Howard University, Washington, D. C. S. S. Davis, L. K. Downing.

BELL, JAMES W., Placement Director and Assistant Professor of Engineering, Lowell Textile Institute, Lowell, Mass. M. E. Gelinas, M. Hindle.

BERGER, J. ALFRED, Acting Head and Associate Professor, Department of Metallurgical Engineering, University of Pittsburgh, Pittsburgh, Pa. R. C. Gorham, P. E. Rush.

BERNINGHAUSEN, DAVID K., Librarian, The Cooper Union, New York, N. Y. C. H. Young, K. E. Lofgren.

BIGGERSTAFF, JOHN S., Instructor in Mathematics, Drexel Institute of Technology, Philadelphia, Pa. F. H. M. Williams, D. Dowell.

BILYK, MATTHEW H., Assistant Professor of Machine Design, Stevens Institute of Technology, Hoboken, N. J. M. R. Reeks, N. J. Rose.

BUDY, JOSEPH J., Instructor in Electrical Engineering, Milwaukee School of Engineering, Milwaukee, Wis. F. J. Van Zeeland, F. Kaufmann.

BURNS, F. J., Associate Professor of Mechanical Engineering, Newark College of Engineering, Newark, N. J. J. L. Polaner, P. Mainardi.

CHURCHILL, STUART W., Instructor in Chemical and Metallurgical Engineering, University of Michigan, Ann Arbor, Mich. E. H. Young, R. C. Walker.

DAVIDSON, ROBERT F., Assistant Professor and Chairman, Mechanics Dept., Missouri School of Mines, Rolla, Mo. R. A. Schaefer, J. W. Rittenhouse.

DE WILDE, ANDRIES C., Instructor in Engineering, Detroit Institute of Technology, Detroit, Mich. L. L. Henry, E. A. Lucitte.

DOERINGER, CHARLES E., Lecturer in Electrical Engineering, University of Toronto, Toronto, Ont., Canada. L. S. Lauchland, G. E. Tracy.

DOWNING, REGINALD H., Dean, Resident College, USAF Institute of Technology, Dayton, Ohio. J. H. Belknap, H. P. Hammond.

ELIAS, EDWARD M., Instructor in Engineering Extension, Pennsylvania State College Center, York, Pa. K. L. Holderman, V. E. Neilly.

ERDMAN, FREDERICK S., Professor of Heat Power, Cornell University, Ithaca, N. Y. D. Dropkin, C. O. Mackey.

ESPELIE, ERNEST M., Assistant Professor, Library, U. S. Coast Guard Academy, New London, Conn. S. C. Hollister, R. Werry.

FAVILLE, JOHN, JR., Director, Field Service, Milwaukee School of Engineering, Milwaukee, Wis. H. M. Wermath, F. Kaufmann.

FAY, JAMES A., Assistant Professor of Engineering Mechanics, Cornell University, Ithaca, N. Y. D. F. Gunder, H. C. Perkins.

FITZGERALD, JOSEPH M., Instructor in Chemistry, Newark College of Engineering, Newark, N. J. D. W. Dickey, T. J. Tully.

FOODY, JOHN J., Professor and Head of Engineering, State University Maritime College, Fort Schuyler, Bronx 61, N. Y. C. H. Young, K. E. Lofgren.

GRIMM, C. JAMES, Assistant Professor of Electrical Engineering, Missouri School of Mines, Rolla, Mo. I. H. Lovett, J. W. Rittenhouse.

HARTFORD, ARTHUR F., Supervisor, Employee Relations, E. I. du Pont de Nemours Company, Wilmington, Dela. S. L. Scott, D. W. Durham.

HILL, CLAYTON B., JR., Placement Representative, Employee Relations Dept., E. I. du Pont de Nemours Company, Wilmington, Dela. D. W. Durham, S. L. Scott.

HILTON, HARRY H., Assistant Professor of Aeronautical Engineering, University of Illinois, Urbana, Ill. H. S. Stillwell, J. M. Coan, Jr.

HOOPER, IRVIN P., Associate Professor of Mechanical Engineering, Rose Polytechnic Institute, Terre Haute, Ind. H. A. Moench, C. C. Knipmayer.

HULLEY, OLIVER S., Associate Professor of Industrial Engineering, Purdue University, Lafayette, Ind. H. A. Bolz, H. F. Owen.

ILIO, DOMINADOR I., Assistant Professor of Mechanics, University of the Philippines, Quezon City, P. I. C. J. Posey, J. W. Howe.

KAYS, WILLIAM M., Assistant Professor of Mechanical Engineering, Stanford University, Stanford, Calif. A. L. London, L. S. Jacobsen.

KELLER, EDWARD L., Assistant Director of General Extension, Pennsylvania State College, State College, Pa. K. L. Holderman, V. E. Neilly.

KENNEDY, OWEN W., Assistant Professor of Electrical Engineering, Worcester Polytechnic Institute, Worcester, Mass. T. H. Morgan, D. E. Howes.

KERR, LEWIS W., Instructor, Automotive Dept., Franklin Technical Institute, Boston, Mass. B. K. Thorogood, R. G. Adams.

KLEIN, KURT K., Design Engineer with J. N. De Serio, Consulting Engineer, Buffalo, N. Y. C. M. Fogel, H. M. Gehman.

KRACKHARDT, RUSSELL H., Assistant Professor of Electrical Engineering, Worcester Polytechnic Institute, Worcester, Mass. T. H. Morgan, H. H. Newell.

KRAEMER, EDWIN C., Chief Clerk, Chemistry Dept., Newark College of Engineering, Newark, N. J. D. W. Dickey, F. A. Russell.

KRUEGER, JOHN F., Assistant Professor of General Engineering, Purdue University, Lafayette, Ind. R. W. Lindley, H. A. Bolz.

LAREW, HIRAM G., Instructor in Civil Engineering, Purdue University, Lafayette, Ind. L. T. Wyly, E. C. Thoma.

LEFFEL, R. ERNEST, Assistant Professor of Civil Engineering, University of Colorado, Boulder, Colo. C. L. Eckel, R. E. Rathbunn.

MARSH, ROBERT F., Assistant Professor of Electrical Engineering, Norwich University, Northfield, Vt. W. D. Emerson, R. W. Thieme.

MCEACHRON, KARL B., Manager, Laboratory-Engineering Dept., General Electric Company, Pittsfield, Mass. M. M. Boring, A. Haertlein.

MCGEADY, LEON J., Assistant Professor of Metallurgy, Lafayette College, Easton, Pa. W. B. Plank, E. L. McMillen.

MCKEAN, A. K. F., Associate Professor of Social Studies, North Carolina State College, Raleigh, N. C. K. O. Beatty, R. Hazelton.

MENAND, HOWARD, JR., Lecturer in Mechanical Engineering, Princeton University, Princeton, N. J. J. C. Elgin, K. H. Condit.

MENKE, EUGENE M., Assistant Professor of Electrical Engineering, Union College, Schenectady, N. Y. J. B. Morrison, G. S. Smith.

MILES, AARON J., Professor and Chairman, Mechanical Engineering, Missouri School of Mines, Rolla, Mo. E. W. Carlton, R. H. Young.

MILLER, EARL A., Assistant Professor of Electrical Engineering, Virginia Military Institute, Lexington, Va. J. S. Jamison, Jr., R. J. Trinkle.

MILLER, K. S., Assistant Professor of Mathematics, New York University, New York, N. Y. H. A. Giddings, I. Wladaver.

MINFORD, WALDO E., Instructor in Electrical Engineering, University of Nebraska, Lincoln, Neb. F. W. Norris, O. E. Edison.

MOORE, GEORGE E., Manager, University Relations, Westinghouse Electric Corporation, East Pittsburgh, Pa. J. C. McKeon, G. D. Lobingier.

MOSER, DEXTER H., Head, Engineering Department, North Idaho Junior College, Coeur d'Alene, Idaho. N. F. Hindle, H. W. Silha.

MYATT, DONALD J., Assistant Professor of Engineering, Antioch College, Yellow Springs, Ohio. D. McGregor, J. D. Dawson.

NAU, ROBERT H., Assistant Professor of Electrical Engineering, University of Illinois, Urbana, Ill. J. V. Neal, P. K. Hudson.

NICHOLS, LEE L., JR., Instructor in Electrical Engineering, Virginia Military Institute, Lexington, Va. J. S. Jamison, R. J. Trinkle.

NORVIK, FREDERICK J., Associate Professor of Electrical Engineering, Rensselaer polytechnic Institute, Troy, N. Y. L. D. Runkle, G. K. Palsgrove.

PALKEN, GEORGE, Assistant Professor of Industrial Engineering, Northeastern University, Boston, Mass. W. T. Alexander, H. K. Brown.

PETERS, ARTHUR S., Professor of Mathematics, New York University, New York, N. Y. H. A. Giddings, G. A. Yanosik.

PIPES, LOUIS A., Professor of Engineering, University of California, Los Angeles, Calif. A. B. Bronwell, S. C. Hollister.

QUICK, FLOYD J., Instructor in Chemistry-Physics, Fresno Junior College, Fresno, Calif. J. B. Franzini, A. B. Bronwell.

REIFSNYDER, JOHN G., Assistant Professor of Electrical Engineering, Lafayette College, Easton, Pa. F. W. Smith, L. J. Conover.

RICHARDSON, ARMAND, Associate Professor of Electrical Engineering, A. & T. College of North Carolina, Greensboro, N. C. J. M. Marteena, L. K. Downing.

ROBISON, WENDALL C., Assistant Professor of Electrical Engineering, University of Nebraska, Lincoln, Neb. F. W. Norris, C. W. Rook.

RONEY, ELLIS L., Assistant Professor of Electronic and Radio Engineering, California State Polytechnic College, San Luis Obispo, Calif. C. E. Knott, C. Nadius.

ROSE, ROBERT H., Instructor in Electrical Engineering, Newark College of Engineering, Newark, N. J. D. W. Dickey, F. A. Russell.

RUNG, THOMAS J., In Charge Terminal Study, Pennsylvania State College, State College, Pa. K. L. Holderman, K. Hunter.

RUSSELL, JOHN B., Professor of Electrical Engineering, Columbia University, New York, N. Y. J. M. Garrelts, J. R. Ragazzini.

SCHMIDT, ADELBERT C., Coordinator and Librarian, Milwaukee School of Engineering, Milwaukee, Wis. C. O. Werwath, F. Kaufmann.

SEAGRIST, ELDON J., Engineer, Gas Dynamics Facility, ARO, Inc., Milwaukee, Wis. H. S. Stilwell, A. F. Armsbee.

SMITH, EUGENE W., Vice President, Cogswell Polytechnic College, San Francisco, Calif. R. W. Dodd, R. G. Folsom.

SODERQUIST, ALBERT A., Administrative Engineer, Boeing Airplane Company, Seattle, Wash. B. T. McMinn, H. G. Wessman.

THIGPEN, ARTHUR C., Assistant Professor of Electrical Engineering, Louisiana Polytechnic Institute, Ruston, La. H. D. Richardson, A. B. Bronwell.

THOMPSON, WEBSTER M., Coordinator of Cooperative Engineering Training, College of William & Mary, V. P. I., Norfolk, Va. W. M. Beck, Jr., E. L. White.

WADSWORTH, WILLIAM B., Associate Professor of Electrical Engineering, Worcester Polytechnic Institute, Worcester, Mass. T. H. Morgan, H. H. Newell.

WEBBER, DAVID S., Instructor, Automotive Department, Franklin Technical Institute, Boston, Mass. B. K. Thorgood, R. G. Adams.

WEINWURM, ERNEST H., Associate Professor of Industrial Engineering, Stevens Institute of Technology, Hoboken, N. J. K. J. Moser, A. Lesser, Jr.

WHITING, FRANCIS F., Associate Professor of Machine Shop, California Polytechnic State College, San Luis Obispo, California. J. B. Franzini, C. E. Knott.

WHITSON, LEE S., Professor of Industrial Engineering, University of Minnesota, Minneapolis, Minn. A. M. Severson, J. M. MacKenzie.

YAMAUCHI, YOHIKAZU W., Assistant in Mechanical Engineering, University of Detroit, Detroit, Mich. H. Gudebski, W. P. Godfrey.

YODER, ELDON J., Research Engineer, Civil Engineering Department, Purdue University, Lafayette, Ind. K. B. Woods, E. C. Thoma.

ZINN, ROBERT E., Professional Lecturer, Chemical Engineering, Northwestern University, Evanston, Ill. L. F. Stutzman, G. G. Lamb.

78 new members elected this year

College Notes

The appointment of Gordon S. Brown as head of the Department of Electrical Engineering at the **Massachusetts Institute of Technology** was announced by Dr. James R. Killian, Jr., President of the Institute. Dr. Brown, who assumed his new duties on July 1, succeeded Dr. Harold L. Hazen, whose appointment as Dean of the Graduate School was announced recently .

Everard M. Williams, voted the outstanding young electrical engineer of the United States in 1946, has been appointed Head of the Department of Electrical Engineering at **Carnegie Institute of Technology.** Designer of the oscillator and deflector for the Carnegie Tech 2½ million dollar synchro-cyclotron, Dr. Williams has been a member of the Carnegie faculty since 1945.

Britain's Economic Rise and Decline and Its Implications*

By GEORGE BAEKELAND

Although our civilization may be said to have stemmed from Greece, the greatest development and enrichment of mankind occurred in Western Europe. In that small area enduring works of art and literature were produced and in it evolved parliamentary government and democracy. Modern thought, science, and the industrial arts came to us from that area. The industrial revolution originated in England, within the sphere of Western Europe.

Arnold Toynbee described the industrial revolution as the "substitution of competition for medieval regulations which had previously controlled the production and distribution of wealth." Adam Smith's "Wealth of Nations," published in 1776, advocated the doctrine of *laissez faire*—freedom in industrial and commercial life instead of regulation and restriction—a doctrine which our recent planners and do-gooders have vilified.

The woolen industry in England was carried out as a part time pursuit at home by farmers and their families. There were no overhead charges. The new cotton industry, which marked the beginning of the industrial revolution, was based on machine power and factories. Unlike the woolen industry, it required a concentration of mill hands who became renters instead of home owners, solely dependent for livelihood on the success of mills that failed if overhead charges on heavy investments were not met.

The growing needs of industry and growth of markets developed transportation and banking facilities and improved machinery. Inventions followed because England had markets, capital, coal and iron. To produce machines, machine tools had to be developed. Watt, who invented the steam engine, had to wait ten years before metal-working tools could be devised to bore cylinders of 6 inch bore and 24 inch stroke, and there were no machinists.

Ascendency of the British Empire

The beginnings of the industrial revolution were coincident with a gloomy outlook for Englishmen. They had just emerged from a long and exhausting war. But England had had her trials and setbacks at the hands of Saxons, Danes, William the Conqueror, Spain, and Louis XIV, and Napoleon was soon to try her mettle again. She was never so great as when all seemed lost, losing all her battles but the last one; unprepared for crisis, she muddled through. She was equally unprepared to admit defeat, a characteristic that has so often exasperated foreigners.

After Waterloo the economic center of the world was shifted to England. During the wars of the latter seventeen hundreds and up to 1815, England, shielded by her navy, increased her revenues, population, and manufactures, while improvements in agriculture met her growing needs.

In the 19th century Britain laid the foundation for the first world-wide economic system and became the world's leading naval, industrial and mercantile nation. The character of her people—courageous, industrious, well-balanced and

* Given at General Session of ASEE, Dartmouth College, June 25, 1952.

tenacious—contributed largely to her success in diplomacy and in commerce. The speed of Britain's rise to eminence was matched only by the rapidity of her decline, resulting from a set of conditions over which she could exercise but scant control. For her rise to the rank of foremost country she deserves great credit; for the loss of that position she cannot fairly be rebuked or criticized. Having lost the American colonies, forces beyond her control were set at work that made the change inevitable. She was an importer of food and raw materials and exporter of finished goods.

The Industrial Revolution, which began in England as already noted, gave that country a lead of about a third of a century over other nations. Since her industrial materials had to be imported with the exception of coal, she was the largest importer of raw materials and food. Obviously, it was to her advantage to embrace a policy of free trade which met her peculiar situation so adequately.

In time Britain began to import more than she exported and her agriculture declined. But returns on foreign investments and payment earned by British shipping and insurance companies were compensations. Sterling was the international currency.

Her accumulating capital became too great to invest at home. In the latter part of the 19th century British capital was employed in nearly all parts of the world. Mines, railways, and steelworks in the United States were financed, after our Civil War, with British capital and engineered by Scots and Englishmen. Hers was a world-wide economy and in industrial products other nations found it difficult to compete with her. British capital invested abroad created the roots of industry in foreign lands that were not tight little islands devoid of raw materials and hampered by a small internal consumption. The United States, unrestricted by such limiting factors, was to become a challenge to Britain's supremacy.

In such an economy as Britain's free trade became a necessity and a dogma, but its rigid application had its disadvantages. She imposed no tariff on sugar to protect her colonies, while Germany paid an export bounty on sugar. Her former lucrative West Indian sugar trade (sugar, molasses and rum) was ruined; the islands became distress areas.

Troubled Signs Ahead

In 1879 farming in England ceased to pay and thereafter the production of food declined, a period during which competition increased and exports declined. In 1840 Britain led in pig iron production. By 1897 the United States was underselling the British in London and our production of pig iron exceeded that of Britain by about 10%. *The Economist* (London) of April 16, 1898, remarked, "The fact that the United States is now able to produce pig iron and some forms of steel cheaper than this country, is a serious menace to our foreign trade in the future."

After the Franco-Prussian War of 1870 Germany became a strong, unified nation, a fast-growing industrial world power with which Britain had to reckon. Following 1870 Britain's adverse trade balance rose 20%. Her surplus declined and income from foreign investments shrank. After 1890 there was a heavy sale of foreign securities in London, especially American securities, while death and excise taxes were increased.

We were destined to become the leading industrial nation. Ours was the largest internal market in the world, with an abundance of all manner of raw materials and a rapidly growing population not dependent on foreign sources of goods. Today we possess about two-thirds of the industrial capital and three quarters of the invested capital of the world.

The need to import food to keep her population alive and raw materials to supply her industries placed Britain in a vulnerable position in time of war, a situation that undoubtedly influenced her foreign policy. With uncanny prescience and prior to the Boer war, Brooks Adams wrote, "Great Britain may be not too inaptly described as a fortified outpost of

the Anglo-Saxon race, overlooking the eastern continent and resting upon America,"[1] and he predicted that the United States and Britain would combine for their own safety, "whether or not agreeable to them,"[2] and that the risk of isolation seemed more dangerous than the risk of alliance.

Britain underrated the Boers. Mistakes and a poor showing were made at the start. These errors could have given Kaiser Wilhelm II, predominantly an aggressive military character, the hope and the encouragement for starting the first World War. That war had a crippling effect on Britain's fortunes while it did much to accelerate the strength and capacity of industry in the United States. But the first and second World Wars should not be accepted too readily as the cause of Britain's decline from her former position as the leading industrial and commercial nation; they did, however, accelerate the decline. Circumstances and destiny enabled the United States in the early part of the 20th century to reach the stature of a great nation. She was endowed with a combination of raw materials, population, foodstuffs, geographical position, climate, and a large internal market that made her ascendency possible; and the necessity to meet the demands of her large home market impelled her to develop mass production techniques.

The economic conditions prevailing in the late 19th century and the early part of the 20th resulted in a great increase in wealth and a sense of well-being and confidence. The contemporary scene was completely satisfactory, agreeable, and seemingly permanent. After the first World War many people expected the world to return to the good and comfortable pre-war days. This was the hope and conviction of many. But that war left behind it a world that they would never see again, a point of no return. Only memory could go back to a world that had gone forever.

Any hope for a return to the conditions existing in former days was shattered by the Great Depression of 1929, followed ten years later by the most far-reaching and calamitous war of all times. Eastern Europe and Russia thereafter virtually vanished from trade with the remainder of the world. Political ferment and the dominance of Russia in the Far East stifled markets. Britain and Europe lost their old supremacy and the United States gained by it. The conditions and the climate of the late 19th century lingered for a short time into the 20th century, then abruptly disappeared.

Germany's inflation following the war of 1914–1918 eliminated her debt and produced a large degree of unemployment with attendant low wages. Japan, with its cheap labor and its penchant for copying others' ideas and designs, began to undersell England, particularly in textiles, shipbuilding and light industry. Japan took some of England's lucrative trade in the Orient; her Manchurian coal was cheaper than Britain's.

Before the second World War there was a tendency in many countries to become economically and politically independent and to exploit their own resources, a situation that did England harm. She found it an increasingly greater problem to buy food from the United States because we exported more than we imported; a condition that eventually resulted in a dollar crisis for Britain.

Capital Investment Influenced by Taxation

Economists may be said to be generally agreed that to maintain an expansion of industrial production, 10% to 15% of a nation's income must be reinvested annually in new plant and equipment. In the period between the two World Wars Britain used but three per cent annually for such purpose. Her older industries were losing vitality, and unemployment followed. Her excessively high rates of

[1] P. 81, "America's Economic Superiority"—Harpers.

[2] P. 82, "America's Economic Superiority"—Harpers.

taxation on corporate and personal income, and on inheritance, were in no small measure responsible for this condition.

Since the last war, British industry has been further eroded by the combined influence of taxation and inflation. Since 1939 the level of taxation in Britain has been maintained at more than 40% of the national income.

A study made in 1935 and 1936 by the National Resources Committee, a group composed of leaders in the Roosevelt administration, indicates that the bulk of savings in the United States was made by families having incomes of $5,000 or more. It was found that the capital necessary to finance both new undertakings and the expansion of old ones was derived primarily from the after-tax income of those receiving more than $5,000 annually. In our country, this class, at the time the report was made, tended to spend $3 billion annnually for living expenses and about 74% of all their after-tax income tended to be invested in stocks and bonds.

These facts show how the prosperity of a nation is dependent upon the ability of the more prosperous sections of the population to save and accumulate capital. It is obvious that the part of income taken by government in taxes cannot be saved; and it follows that very high taxes on persons in the upper income brackets tend greatly to hamper the economic progress of a nation. The only sources of capital are the savings of individuals and corporations.

The law of diminishing returns operates in taxation and in revenue as it does in other fields. A study of taxation in the United States shows that a rate of 23% to 25% has brought the highest returns, a condition which cannot be assumed to apply solely to our own country. High taxes in England since the first World War have contributed in no small measure to a decrease in the vitality of her industrial plant; and financial history proves that when taxes consume more than twenty-five percent of national income, industrial decline sets in.

Britain's current confiscatory taxes can have no other effect than to hamper her recovery and in time they may ruin her. Taxation siphons away the money required to keep her industrial plant in repair or to equip it anew Excessive taxation is not a device to increase revenues, but to level society by dividing what capitalism has produced.

Between the two World Wars in nearly all parts of the world the price of finished products, owing to improvements in technology and to mass production, tended to decrease in relation to the price of raw materials and food which Britain was required to purchase abroad. In 1938 she imported 20% more and exported 40% less than in 1913.

Cartels and Industrial Progress

The absence in Britain of laws against monopolistic practices, such as contained in our Sherman and Clayton Acts, is undoubtedly another contributing factor in Britain's industrial decline. Competition between members of an industry in the United States is on a very different footing than it is in Britain. Our incentive to secure markets and ward off competition, domestic or foreign, is greater here, for one member of an industry may introduce a technological improvement that can be ruinous to his competitors. As we so well know, our laws prohibit "gentlemanly" and cooperative relations with competitors, here or abroad. We are forced to rely on efficiency and technological advantages over competitors. Price fixing, patent pooling, and allocation of markets are denied us. If our business relations with competing companies were cozy and friendly there would not be the pressure to employ the large proportion of technical and scientific personnel so characteristic of American industry and in numbers out of proportion with those encountered in British and European companies. Technical advances would have occurred here as they have elsewhere, but our laws regulating trade practices have made it necessary to attain the high degree of efficiency and the technical superiority that characterize American industry.

The premium we have placed on technological progress has been reflected by bonuses, pensions, employment contracts and salaries to scientists, engineers, and chemists, and on their status in the companies employing them. In many of our companies they attain important executive positions. After receiving a doctor's degree in chemical engineering or physics our students, on leaving universities, are offered by industry salaries of six to seven thousand dollars. The contrary is the rule in Britain, where technical men are poorly paid and their social status is low. The salaries of civil service scientists run from $1,800 to $3,000 a year. Research workers have to punch time cards, while senior lecturers in universities have to wash their own glassware. Such unattractive conditions have resulted in an acute shortage of scientists and technologists in Britain.

Rising Socialism

When the telegraph and telephone were introduced in England these services were taken over by the Post Office. Public utilities, too, were socialized in the last century. Britain got some of the virus of socialism rather early, a disease hard to shake off once the victim has got his feet wet. Her situation during the last war led her to resort to socialistic restrictions upon her people and economy which have not been relaxed. The creeping paralysis of Statism and the Welfare State struck England more forcibly than it did us and, to date, has gone farther. Her output per man hour has declined, as has her coal production. Without sufficient coal the underpinning of Britain's commercial power is destroyed.

The British tax load is so great that incentive is undercut by reducing the penalty for shiftlessness and reducing the rewards for doing something. Very little individual income is left available for investment or purchases.

In 1880 George Bernard Shaw and a group in England formed the Fabian Society with the avowed purpose of reconstructing the British economic system. Not interested in creating more national wealth, they sought only to achieve a leveling process, a re-distribution of wealth. The restrictive measures and high tax rates imposed in the course of two world wars did much to accelerate the blight that now pervades the British nation.

In January of this year *Time* magazine quoted Lord Beveridge, who lately spearheaded Britain's Socialism, as saying, "There has been too much leveling down. It is not posible for anyone, however hard and well he works, to enjoy the kind of income or to make the savings for old age that were easy when I was a young man. Just from where, in our classless collection of men and women, leadership will come . . . I do not know."

Britain has a badly worn out plant that has been running to capacity for years and inflated prices that add to the difculty of reinvestment in plant. Her depreciation charges are not enough at present price levels and the tax load has been increased on the earnings left after depreciation charges. Her machines are worn out and inefficient: obsolete tools cannot rapidly be replaced. Her productivity has suffered a severe loss. Her steel production in 1951 showed a decline from 1950, the only nation to show a decline, probably the result of nationalization of steel.

The last war ravaged all of Europe and Western Russia. The Far East, too, suffered from war damage and civil strife. Britain became dependent for supplies on the Western Hemisphere, which was unaffected by war or by climatic or civil crises, an area that had burgeoned under the impetus of a war economy. Between 1939 and 1944 our national income doubled. There have been two ways to obtain high produvticity and, in turn, prosperity: the former American way of rewarding incentive; and the old idea of slave labor used by Babylon, Greece, and Rome and now being tried by Russia. Britain's present Share the Wealth is in between. Incentive is killed by high taxes and her Government is not strong enough to control Labor, troubles we currently share with her if only to a lesser degree.

The locus of civilization and commerce moved westward, from China, Babylon, Greece, the Italian peninsula, the Low Countries and France, to England. Presently, economic leadership resides in the United States. Should this movement be guided by natural law—it could be coincidence—we might expect ascendency in Eastern Asia and a decline on the North American continent. The great land mass now under Russian control, in whose outpost we are presently engaged in an uneven struggle, has a vast population, a great store of natural resources, and possibly the capacity to feed its hordes: a challenging spectacle even to those who would discount the theory of natural law.

The Choice of Destiny

While dwelling on so dreary a prospect, and whether natural law or coincidence has determined the course of history, it might be interesting to speculate on what might have happened if the stupidities, the narrow views, and the injustices prevailing during the rule of George III, combined with a dislike and resentment against America, had yielded to those in England who showed wisdom and better judgment. Britain would have had America on her side during the wars with France; the War of 1812 and the bitterness that lasted for generations would have been avoided. Of course, the mere mention of such a supposition might be considered heretical, but that it did not and cannot now happen should put at ease those who sense a trace of heresy. Inevitably, industrial supremacy would have moved to North America for reasons already mentioned, i.e., climate, food, natural resources, geographical position and population but economic growth on the North American continent would in all likelihood have been less rapid nor would there have been such a rapid flood of all manner of immigrants. With control of North America it may be supposed that Britain's economic supremacy would have lasted indefinitely longer. We are reminded that our Monroe Doctrine was predicated on her naval dominance and her policing power. With the resources and manpower of North America under the British flag it is unlikely that any nation or probably combination of nations could have been a serious challenge.

Her colonial empire would have remained intact and our political status would have become akin to that of Canada. The two World Wars of this century would probably not have occurred, because Britain's growing weakness each time invited them. The Pax Britannica might be keeping order in this disordered world today. Speculation on speculation, and argument as well, could be added, but there seems to be some basis for the supposition that our victory in 1776 may not have been wholly an unmixed blessing in the light of present world problems and dangers. Britain herself came close to revolution during those days, for reasons that prompted the revolution here. The injustices that caused it and likewise prevailed in England were corrected there not long afterward.

America's Excursion in Internationalism

Our first excursion into internationalism occurred when Britain and France faced defeat in World War I. It became apparent that full American support would be necessary to prevent Germany's conquest or domination of Europe and probably Russia and the Dardanelles. Our own interests impelled us to prevent both the disintegration of Britain's mercantile empire and the economic status of Europe: we feared the prospect of an all-powerful Germany dominating Europe. Isolationism for the United States then ended but was resumed when we declined to join the League of Nations; and isolationism continued to be our policy until self-interest again prompted us to rescue our former allies from the menace of Hitler's Germany.

Had our own so-called statesmen not been so artless and simple we might have gone back to minding our own business after the second World War, to returning in larger measure to what is termed isola-

tionism but more properly might be referred to as nationalism.

Isolationism appealed to the many who so rightly sensed that we were ill-fitted for and irresponsible in foreign affairs, as witness only the irreparable folly at Teheran and the cupidity at Yalta, then the awful stupidity of our President and Secretary of State at Potsdam by giving in to the Russians while we had in the field the greatest military force of all times. Perhaps, they believed our Ambassador to Russia, who wrote the following in "Mission to Moscow": "In my opinion, the Russian people, the Soviet government, and the Soviet leadership are moved basically by altruistic concepts. It is their purpose to promote the brotherhood of man. They wish to create a society in which men may live as equals, governed by ethical ideals. They are devoted to peace." Our isolationists must have sensed that American know-how was sadly lacking in the field of diplomacy.

Our foreign policy is initiated by our presidents, party bosses raised to eminence, we usually appoint generous campaign contributors to become ambassadors, and party politicians as Secretaries of State. Is it any wonder they so often do so badly for us?

Goethe in 1831 remarked, "I hate all bungling like Sin; but, most of all, bungling in State affairs, which produce nothing but mischief to thousands and millions."

Until the early part of the last century, incompetence, bungling and corruption were as rife in English politics and administration as those evils are with us today. Patronage was abolished and a Civil Service, trained in special schools, took its place. When England's Augean stables were cleaned out, Andrew Jackson set them up in business over here. We did not ape the English that time.

Universal Sufferage and Socialism

The quality of public office in Britain improved and a debasing factor in public life was removed. The British Civil Service is perhaps the best in the world and the least affected by the faults of bureaucracy. Independent bodies of experts known as Royal Commissions are appointed to study problems and render reports prior to legislative action, a very useful system. When a government changes, hardly a hundred officials lose office—practically all public offices depend on competitive examinations.

As John Truslow Adams, the American historian, wrote, "A privileged governing class who do not have to worry about money and who are genuine in their desire to lead in a noble and independent fashion may fall below their privileges and opportunities and get out of touch with the people at large. Yet, on the other hand, a democracy, as is evident today, may show itself unable to produce capable leaders of both party and country."[1]

A factor that may have assured Britain good government for so long a time was the very gradual granting of the franchise. Not until 1884 was it extended to male heads of households. Although unqualified universal suffrage has become a fetish to many, there is no gainsaying the fact that granting to every citizen the right to vote with no other qualifications than that he or she be twenty-one years of age and not in a prison or an insane asylum has its drawbacks; no family, business, ship or farm could be expected to do well under such a system, and from all evidence no exception can be made for nations. The trend toward Socialism and the general decline in statesmanship in our own country and in others may be the result of several influences, but the advent of unqualified universal suffrage appears to share a large part of the blame.

When the executive and legislative are recruited by unqualified universal suffrage, every act must be popular and socialistic or votes are lost. The demands of the mediocre direct the acts of government. As the base of suffrage is extended so does legislative action become more debased, and the pall of mediocrity descends upon a nation. In time the frustrated masses

[1] "Empire of the Seven Seas"—J. T. Adams, Scribner.

call for a leader to curb the Frankenstein their own demands and votes have created, a political savior who will do all their thinking and acting for them. How often we hear that call in our country today, as witness only a call for a leader in an editorial in the *Saturday Evening Post* of May 3rd. Bread and circuses lead to single party governments and dictatorships, and it is likely that all countries that succumb to the folly of unqualified universal suffrage will in time go through the wringer.

Tragic Consequences of Appeasement

The second World War and its tragic effects on the world in general did more than all else to reduce Britain to the pitiable condition which currently prevails there. Had that war been prevented, as so easily it could have been with a modicum of statesmanship and political courage, unpopular with the British masses, she would today be a proud and strong nation, notwithstanding the fact that industrial supremacy had inevitably been shifted to North America.

Germany's resurgence as a great military power could have been stopped at any time in the early or middle 1930's by enforcement of the Treaty of Versailles through the League of Nations, as could Italy's sally into Abyssinia. Britain was the main prop of the League and what she did or refused to do was to determine the course of history.

When Mussolini attacked in Abyssinia and Hitler openly flaunted the provisions of the Treaty of Versailles by rearming Germany and instituting conscription, Stanley Baldwin was seeking re-election of his party by promising all things to all voters. During that campaign he strongly advocated the need for rearmament and a stronger navy but to placate the pacifists he said, "I give you my word there will be no rearmaments" and added, "There will be no war." After his party won the election he pursued a peace-at-any-price policy which prompted Mussolini to change sides by allying himself with Hitler, who henceforth was no longer isolated. When Winston Churchill took Baldwin to task for not getting Britain prepared, the latter replied, "I cannot think of anything that would have made the loss of the election from my point of view more certain."

During this critical period the United States, a signatory to the treaty of peace and its principal architect, considered it wise to have nothing to do with the foreigners. We were preoccupied with "taxing and taxing, spending and spending," too busy leaf-raking, badgering businessmen and setting up a Utopian Welfare State to concern ourselves about enforcing the peace we had won at the cost of so many lives and so much treasure We have looked upon war not as an instrument of diplomacy but as a football game; when the game was over we tore up the goal posts, threw our hats into the air and went home.

Whereas in the past insularity has protected us from attack, it likewise made us less skilled in world affairs. Our geographical position has isolated us and made our people possibly the most provincial of any of the great nations, except Russia. As a result, Americans have not understood the habits of mind, the manners, the reactions, prejudices, or ways of foreigners: our dealings with them and our diplomacy have suffered for that reason. As an example, taken within our borders, it is recognized that a Southerner is far more adept than a Damyankee in dealing with negroes; the Southerner knows, hence understands negroes.

Britain's decline and our ascendency impose on us new responsibilities and duties, unequal to them as we presently seem. The problems and perils confronting us cannot adequately be met by the calibre of statecraft displayed here to date. We have succeeded to Britain's former world position and exceeded it in nearly all respects except in governmental administration and in diplomacy. Unless we correct that weakness, historians will be writing the cause of America's decline as the course of Empire again moves Westward.

A Procedure for Teaching Fundamentals*

By FREDERICK W. ROSS

Professor of Aeronautical Engineering, University of Detroit

We in engineering education are faced with this problem: With the rapidly increasing amount and complexity of engineering technical information how can we give the engineering student a good sound education? Shall we continue to cram the student with more and more specialized technical information or shall we emphasize the teaching of fundamentals?

Practical Procedures Needed

In aeronautical engineering alone reference to the college catalogue for one large university shows that the student would have to attend some four or five years after becoming a junior to complete all the specialized and pertinent upper division subjects offered. Not only would this require a total of six to eight years of college—a circumstance which would probably interest very few students—but because of the rapid obsolescence of such specialized technical information a sizable proportion of the subjects learned early in the course would even be obsolete before the student was graduated.

This situation is of course handled, generally at present, by requiring the student to elect a specialty within a specialty. This is a good expedient perhaps—but it gives the student only a narrow training and not a sound education. Also, what happens to the student who chooses a specialty that becomes obsolete or a specialty he finds impractical to pursue as his life work?

These and many similar facts have become more and more apparent in the past ten to twenty years. They pose problems we all know must be solved.

In contrast to this situation we observe that certain fundamentals are basic to all engineering fields and that these fundamentals have a much longer period of active useful life and more generally outlast the engineer himself. In consequence we ask: Shall we emphasize the teaching of these fundamentals rather than continue to cram the student with more and more detailed information?

This question may be viewed in two ways:

(1) Should we emphasize fundamentals? and
(2) If so, how can we do it?

Considerable has been said and written on these two questions, principally the first, showing why it is advantageous to teach fundamentals. While perhaps we don't all agree with all that has been said, I believe that we all, more or less, agree with the general idea. Yet, we ask—How can we, in a practical way, teach fundamentals effectively and yet turn out technically sound engineering graduates?

I believe the entire problem even though excellent in principle, will stand or fall depending on whether a good practical way of doing the job can be found or not.

Present Curricula Preferable

There are two ways of approaching the problem of teaching fundamentals:

(1) To rearrange the subject matter (curricula) to fit in additional courses involving fundamentals, or

*A paper given before the University of Detroit Section of The American Society for Engineering Education at the University of Detroit, April 4, 1952.

(2) To work out new methods of teaching to emphasize fundamentals within the framework of present curricula.

The second approach has three imporant advantages:

(1) The fundamentals can be made more realistic and interesting to the student if taught in surroundings as near the real thing as possible, (2) no immediate change in administration of curricula need be made, and (3) by making the changes within the framework of present curricula any necessary changes in curricula can be made gradually as the work evolves rather than by requiring drastic immediate changes. It seems reasonable to expect that any practical solution to the problem of teaching engineering fundamentals must be carried out at class room level between instructor and student in terms of subject matter already deemed, by previous experience, to be important enough to be included in present curricula.

Many of the elements discussed here are already well known. It is felt, however, that the manner in which they are used offers improved effectiveness. For that reason I should like to pass along my experience to date in trying to evolve a procedure for emphasizing the teaching of fundamentals within the framework of present curricula.

Results to Date

About a year ago, while teaching a course on airplane stability and control, it occurred to me that here was a course which might lend itself advantageously to the emphasis of fundamentals. The subject matter involves the most advanced aerodynamics interrelated with rigid body dynamics in six dimensions. The complete solution of such a problem involves a system of six differential equations with complicated variable coefficients.

Although this is a senior course, the subject cannot be handled in ten weeks even if the students had the necessary mathematical and aerodynamics background.

In this course then we have a choice of

(1) giving the student a mass of miscellaneous information with no more than a vague idea of what it is all about, or
(2) we can try to give him a sound fundamental foundation to build on.

Knowing from previous experience that the first approach, the descriptive approach, left much to be desired, I ventured to try the fundamental approach.

The results of this first attempt were like this: Rather than gaining a nodding acquaintance with a mass of detailed stability information and a rather vague notion of how it is all related to the whole stability problem,

(1) Over two-thirds of the class showed a fairly mature grasp of the fundamentals involved.
(2) Two students, except for minor numerical errors, completed a difficult final exam for which the instructor took nearly the entire period to work.
(3) Only two students were lost in the details (as is generally the case for the majority of students with the usual more descriptive presentation).

These results seemed sufficiently encouraging to go further into the matter. Since then constantly improved versions of the procedure have been tried in six or eight different classes including aerodynamics, theory of compressors and turbines, and fluid mechanics as well as the course on airplane stability and control.

Outline of Procedure

The procedure is simple and—a point of interest to all instructors—easy on the instructor—less detail need be prepared.

The teaching of fundamentals must start with the instructor. He must break the subject down into the most elementary essentials and show how the essentials are related to the many ramifications he in-

tends to illustrate. This may require a slightly different view of the subject, but along with this and what detailed engineering information we all have from our own experience, the instructor is well equipped to apply the method.

The fundamentals must be presented in the simplest, clearest terms possible for the stature of the students. If the instructor has a thorough grasp of the subject this approach will be the easiest to present; if not, then such a preparation will add much to his understanding of the subject and hence to his ability to put it across.

The method as evolved to date may not be directly applicable to some courses such as those involving mainly descriptive matter or to large lecture classes. Perhaps some aspects of the procedure could be adapted in such cases, however.

Briefly the method may be outlined as follows:

1. Student Participation
   (All analyses, including newly presented subject matter, theory, and problems, are accomplished entirely by class discussion—mainly by question and answer method.)
   A. Orientation
      (Accurate but informal definitions are presented in terms of students' background including previous engineering, science, and mathematics courses *as well as everyday experiences.*)
   B. Follow-up (Feedback)
      (By question and answer find out if the students are with you at all times—if not, slow down until you are together.)
   C. Repetition of Fundamentals and Their Applications
      (Every time a fundamental is needed in a derivation or a discussion ask a student to furnish it and to trace through its implications.)

This student participation can usually be conducted as a round-table discussion. This informal approach opens the student to the subject and removes the mental block often present in more formal presentations. It gives him practice in thinking in terms of fundamentals much as he does other things in life and in addition gives him practice in extemporaneous speaking. It provides a way for him to gain confidence in his own ability to cope with problems by using his own mental faculties rather than by leaning on books or instructors.

2. Programming (not scheduling)
   A program is an outline or *order of events* to be pursued, while, on the other hand, a schedule is a statement of *time of projected operation.* (Rather than hurry from one subject to the next to meet a given time schedule we should take the important material in program order, i.e., "finish" each topic before starting the next. At a musical concert each selection is finished before starting the next—certainly an education is more important to the student than the playing of a piece of music. We should try to cover each step well before going on. It is more important to gain a better understanding than to cover more subject matter. In applying this, of course, judgment must be exercised. Sufficient time cannot be allowed for unusually slow or careless students, and in some beginning subjects understanding is not always possible the first time a subject is presented. It certainly applies, however, to most upper division courses.—This is discussed further later.)
3. Analysis Breakdown
   Neat systematic summary
   (It is preferable that all items in a, b, and c below be given in terms of some kind of "short hand" notation or in terms of symbols or mathematical relationships where possible so that the larger logical steps can be visualized more readily without being lost in too many details.)
   a. Items given directly (direct knowns)

b. Items implied (indirect knowns)
c. Unknowns

4. Distinguish the Concepts Involved

a. Physical concepts
b. Mathematical aspects
c. Units problem
(By the use of symbols appropriate to the problem each problem or derivation should be divided into smaller steps which are thus each shown in a simple mathematical relation to the whole problem —see example cited later for further explanation.)

5. Closed Book Examinations
(Closed book examinations are preferable. The student should learn to think by himself without leaning on a book or answer book, or an instructor. It is felt that this is important in helping the student gain confidence in himself.)

Correlated Principles

In order to apply the method more effectively the following important principles should be well understood:

1. Cross Roads Principle
The class room is a cross road—every student, including those having had the same courses, comes to class from a different "mental" route. They usually have much in common but still their degree of understanding is often widely different.
2. Vague Notion vs. Working Understanding
The distinction between these two items must be constantly kept in mind. Engineering (both design and analysis), like thinking, is an art. Anyone can get the vague notion of how to play the piano in a few hours. To become a concert artist requires years of concentrated effort and practice. So it is with engineering—the student must *practice* the use of fundamentals in the solution of important engineering problems before he can really make use of them in the solution of difficult problems.
3. Latent Ability and Knowledge
Most students have much ability and knowledge lying dormant in their minds. If these latent abilities can be drawn out a few times by, say, the question and answer procedure, or by closed book examinations, the students learn to appreciate what they can do for themselves. Usually their interest and enthusiasm rise accordingly, and once they find it out they develop much more rapidly from their own increased interest.
4. Mental Economy Principle
It has been said that there is no limit to what most people will do to avoid thinking—consequently almost everybody is looking for some special short cut formula—some easy way out—to avoid thinking. By examples, drawn from problems and experiences, the students can be shown, especially in the complex engineering problems of today, how much they can save in time and effort by good sound analysis—*the real short cut.*
5. Reflection (or Follow-through)
All students should be encouraged to appreciate that when the first answer to any problem is obtained, the problem is only about half finished. It must be checked—rearranged—presented. It must be reviewed to gain an over-all perspective of the principal points of concern. In the class discussions this is done by repetition (Part 1 c. above).

Discussion of Method

The use of student participation, involving orientation, follow-up and repetition, and the use of programming rather than a time schedule, will in some cases require additional time. Experience has shown that although most classes may be considerably behind by mid-term, sometimes, and particularly in senior courses, they go farther before the end of the term. Because of the basic nature of engineering fundamentals and analytical methods to all engineering subjects, it seems reasonable to expect that if students study using these methods for several successive

courses much momentum will be gained so that any loss which may be experienced at first will be more than regained before they are graduated.

Two examples will be discussed to illustrate some of the more important points of the procedure.

First, let us consider part 3 b. of the Analysis Breakdown, entitled "Items implied" or "Indirect knowns." Such items include all pertinent general principles implied as well as all pertinent mathematical relations implied. To illustrate the former, consider the following problem: an airplane glides from a height against a headwind. What is the maximum horizontal distance the airplane can glide in terms of known aerodynamic characteristics? This problem usually stumps even the best of students—until they can appreciate and understand the one simple fact—that the airplane flies in the surrounding air (i.e. relative to the air) and that any aerodynamic analysis must be set up in terms of the surrounding air rather than the ground. Once this simple fact is really understood the problem is easily solvable. Then the student can readily see why—although the airplane flies in "still" air, which is moving past the earth, the magnitude of the headwind requires a change in the manner in which the airplane must be operated in order to glide the maximum horizontal distance.

Second, as a further example of "Items implied" and to further illustrate the distinction between 4 a. "Physical concepts" and 4 b. "Mathematical aspects" as well as the "Units problem" (4 c.). Consider a fluid flow problem involving energy balance. Given: a fluid flowing in a conduit from station (1) to (2)

The main "Physical concept" is very simple:

By the law of conservation of energy—the energy at (1) plus heat or work added less heat or work removed is equal to the work at (2). Any junior student who can count money can understand this—he has so much money in his pocket, he spends so much, he earns so much, he has so much left. Have him write it down in terms of the energy in the fluid something like this: if e_1 is the energy in the fluid at station (1) and e_2 at station (2), then

$$e_1 + \text{heat or work added} - \text{heat or work removed} = e_2.$$

In any particular application each of these quantities must be evaluated. For example, in an adiabatic expansion no heat or work is added or removed, hence $e_1 = e_2$; in a compressor work energy is added to the fluid, no heat is added or removed, hence $e_1 + W = e_2$; in a turbo-jet engine heat is added by a burner and work is removed by a turbine and added by a compressor, thus

$$e_1 + Q - W_t + W_c = e_2. \qquad (1)$$

It is important that this simple concept be determined and clearly understood before attempting to evaluate each separate item. Thus the major items which enter into the problem and the manner in which they enter can be clearly understood without complication of the details of evaluation of each major item.

The next step is the evaluation of the major items. These can often be broken down into smaller units. For example, the energy in the fluid at station (1),

$e_1 =$ (kinetic + gravity potential + pressure potential internal + chemical + nuclear + etc.) energies.

The detailed mathematical expression of each of these items is a separate problem and need not be confused with the main problem. To illustrate this aspect consider a problem involving only the first four types of energy. Then,

$$e_1 = \tfrac{1}{2}v_1^2 + z_1 + p_1/w_1 + Ju_1. \qquad (2)$$

The student need not consider the matter of units in the problem until he reaches

this point. Thus any confusion of units is separated from the main problem.

The substitution of these detailed quantities into a relation such as eq. (1) is simple and almost trivial, and all students can handle it immediately, and hence the problem is like an open book, easy to visualize, easy to check. The student then by the use of simple algebra derives his own equation for this particular problem as

$$\tfrac{1}{2}v_1^2 + z_1 + p_1/w_1 + Ju_1 + Q + W_t - W_c = \tfrac{1}{2}v_2^2 + z_2 + p_2/w_2 + Ju_2. \quad (3)$$

No emphasis is placed on this resulting equation. In the class each problem is started from the simple fundamental relation which is the basis of equation (1). *In this way the student understands that equation (3) is the algebraic solution to a particular problem rather than a formula.* He has the understanding and is then able to set up similar problems for any circumstance required rather than to use a general formula similar to equation (3). By "opening the problem up" in this way, such things as sign conventions which are easily susceptible to error, and checking difficulties are avoided—and a very important point—the student has an effective simple way to check the problem, either in the manner of application of the various terms or in the units.

The essence of the analysis then is to analytically "open the problem up" so that the student can see the main problem and so that he can isolate the details that cause trouble. Thus he can concentrate his effort on the difficult parts after removing the masking effect of the things he knows. Thus it is usually found that the difficult parts aren't as difficult as at first appears, as is usually the case when he tries to solve the whole problem by "insight" or at a glance or by a formula.

When presented in this "open" analytical way, in the friendly round table discussion method, illustrated by numerous examples, the student soon finds out how much better he can understand the problem, how much more easily he can check his results, and how easy it is to trace down errors and to make modifications to fit other problems—then he begins to gain confidence in his own abilities—and can begin to stand on his own "mental feet."

This manner of analysis has another important aspect. It prepares the student to fit into a supervisory capacity.

If the energy problem just discussed were a problem which required a large number of persons, then the student who has a working understanding of these procedures is in a position to supervise or administer such a problem most effectively. Thus the chief engineer sets up the main problem (represented by the relation $e_1 + Q - W = e_2$, e.g.). He then arranges his organization to have one division handle each part (represented by e_1, Q_1, W_1 and e_2 respectively). Each of these divisions headed by a divisional supervisor in turn can separate his division into smaller departments (e.g., e_1 can be separated into kinetic, chemical, etc. departments—each with a department head). As in the analysis of problems, so also in the administration of larger problems by "opening the problem up" by analysis the difficult phases can be separated from the simpler. Thus the administrator can appoint the more capable and better qualified persons to handle the more difficult phases but need not have such highly specialized persons for all parts of the problem. He can concentrate the effort where needed.

The importance of analytical experience gained in this way to the administration of technical problems it is believed is invaluable, and should help prepare the way for administration in broader fields.

Summary

In summary, it is believed the student who can analyze problems in this way should be prepared to become a competent engineer—he knows how to go ahead by himself—he develops self-confidence, he starts to think for himself, he learns how to separate the unimportant details from the important and difficult issues. It is believed that this is what we want to give the student—a good sound engineering education.

The Status of Engineering Economy*

By WILLIAM D. McILVAINE, JR.

Director, Engineering Extension and Placement, University of Alabama

Why and How of the Survey

In discussing the problem of how to encourage more schools to teach Engineering Economy and to get more students to study the subject, the Engineering Economy Committee asked that a survey be made of the present status of the subject. A preliminary questionnaire was sent to each school offering four or more years of engineering education as listed in the Educational Directory published by the U. S. Office of Education. This first questionnaire, among other things, requested the name of the individual in charge of the teaching of Engineering Economy in the event that the school offered the subject. A second questionnaire was sent to this individual to get the complete details on the manner in which the subject was taught. In each of the questionaires, the subject of Engineering Economy was defined as "the body of principles involved in making a wise choice between engineering alternates." To give further substance to the definition, the questionaire stated, "The course usually includes a study of prospective rate of return, interest, annuities, depreciation, financial statements, comparisons on the basis of present values and expected annual costs, replacement problems, etc."

Statistical Results of the Survey

To get a broad picture of what engineering colleges were recommending to their students to acquaint them with the principles of business practice, the questionnaire asked the approximate percentage of students taking work in the following four fields: Engineering Economy, Economics, Accounting, and Business Principles. Table I indicates the results of the returns from 122 of the 150 schools contacted.

The following facts have been gleaned from the returns from the 57 schools that reported that they taught Engineering Economy and who gave sufficient information. Table II indicates the frequency with which Engineering Economy is required or frequently elected in each of the 18 curriculums.

Table II gives some interesting information when you note the ratio of the number of schools *requiring* Engineering Economy to the number of schools *offering the subject as an elective.* It is evident that the Industrial Engineers with their 26 to 1 ratio value the subject very highly. The Civils also hold it in high esteem with a ratio of 33 to 10. The Electricals and Mechanicals appear to regard it as important but not essential since their ratio of required to elective is approximately 5 to 4. It is evident that those schools who have organized a course in Engineering Economy do regard it as important since the totals indicate it is required in 152 curriculums and elective in 90 curriculums.

The most popular text appears to be Grant's "Principles of Engineering Economy" with 24 courses in which it is the only text, and 5 courses where it is used in conjunction with some other text. Four other texts are closely grouped as also popular. Woods and DeGarmo was used

* Presented before Engineering Economy Committee of the American Society for Engineering Education, June 26, 1951, Lansing, Michigan.

in 7 courses and in one other course in conjunction with another text. Thuesen was indicated as the sole choice in 6 courses and as a joint text in 3 others. Canfield was adopted in 5 courses and Bullinger in 4 courses with a fifth case where it was used jointly.

The second questionnaire also asked for a statement of the prerequisites for a course in Engineering Economy. The most popular prerequisites were: Senior standing (16), Junior standing (11), and principles of economics (9). Several schools related Engineering Economy to earlier courses in Accounting or Industrial Management. Columbia specified calculus, accounting, and corporation finance as prerequisites. From the results of the questionnaires I presume that much can be done to more effectively relate the study of engineering economy to the study of engineering design, business principles, accounting, statistics, and economics.

The average Engineering Economy course is equivalent to 3.7 quarter credits when we consider only those courses that are strictly limited to the field of Engineering Economy. One school presents the course in the sophomore year, 11 in the junior year, 38 in the senior year, and 1 in the 5th year of a 5-year curriculum. The philosophy behind the 4th year place in the curriculum is that the seniors will be getting a taste of design problems in some field of engineering at that time. However, a number of schools are now convinced that the general principles of Engineering Economy should be presented in a fairly elementary manner at an earlier date so that the student will be better prepared for the transition from the study of science to the study of engineering design.

TABLE I

AVERAGE PER CENT OF STUDENTS TAKING ONE OR MORE COURSES IN EACH OF THE FOLLOWING SUBJECTS

Subject	Average %
Engineering Economy	40.6
Economics	92.1
Accounting	23.4
Business Principles	25.4

TABLE II

NUMBER OF SCHOOLS IN WHICH ENGINEERING ECONOMY IS REQUIRED OR FREQUENTLY ELECTED FOR EACH CURRICULUM LISTED

Curriculum	Number of Schools Requiring	Number of Schools Electing
Aeronautical	9	6
Agriculture	3	5
Architectural	3	4
Ceramics	2	2
Chemical	9	10
Civil	33	10
Electrical	20	16
Engineering Physics	1	4
General	5	2
Geological	4	0
Industrial	26	1
Mechanical	24	19
Metallurgical	2	2
Mining	3	1
Petroleum	3	3
Sanitary	4	1
Textile	0	1
Other Curriculums	1	3

The average engineering student becomes intrigued with the problem of obtaining "exact" numerical answers and it is healthy for him to make an early acquaintance with the fact that the most difficult type of problem is that of making a choice between several answers, none of which is "exact."

Interpretation of Objectives

What are the real objectives of Engineering Economy and how important are they in Engineering Education? If only 40 per cent of our engineering students should have an introduction to the principles of wise and economic choice, how are we going to choose the right 40 per cent? Or should *all* engineering students have an introduction to Engineering Economy? Or are we on the wrong track altogether, and should we return to the policy of teaching the fundamentals of science, a little about the techniques of modern design, and nothing else?

It seems obvious that present trends in engineering education are toward breadth. A number of engineering educators in

replying to the questionnaires emphasized this fact and particularly the fact that Engineering Economy was designed to accomplish this purpose. A typical statement was that of Professor J. F. Manildi, University of California at Los Angeles, who stated, "It is our strong feeling that our course in Engineering Economy is indispensable in the engineering curriculum. We feel that an engineering graduate is not properly qualified to handle everyday engineering problems on the job unless he has an appreciation of the influence of the economics of the situation on the technical aspects of the problem." This does not indicate that a course in Engineering Economy will broaden a student to the extent that is desirable, but it does indicate that it is an opening wedge in getting the engineering student to consider the value of other than purely technical studies.

Evaluation of Present Practice

The average course in Engineering Economy does seek to acquaint the student with enough of the vocabulary of accounting, business practice, finance, etc., so that he can work intelligently with management. In addition, the course gives the student some techniques of analysis that will enable him to deal with technical problems in which first costs and continuing annual costs are factors. All of these studies are directed at helping him understand the problems of an individual business. He may even get a little glimpse of how factors such as taxation, price levels, etc. affect the individual business and this may give him some curiosity in regard to these factors.

It is my belief that the study of Engineering Economy with its concern for the problems of the individual business unit is much more elementary and basic than a study of the topics included in the average course in the Principles of Economics. I agree that Economics has greater breadth than Engineering Economy if each course actually teaches what it proposes to teach. I also agree that an understanding of Economics is a prerequisite to a stable functioning of a democracy. However, my experience in dealing with students who have studied economics in their sophomore or junior years is that they have gained a very trivial comprehension of the material included in Principles of Economics.

A much more logical plan for effectively broadening engineering students is to teach them something about the operations of an individual business enterprise before we attempt to help them understand our economy as a whole. Good teaching in practically any field seeks first to describe units and then to describe systems. How can a student understand a system until he has acquired at least a good acquaintance with the components of the system. Why don't we teach Engineering Economy in the junior year and Economics in the senior year, or at least teach the courses in this order?

From the standpoints of motivation and effective teaching, this arrangement seems much more desirable. A junior is eager to engage in a discussion of problems that appear to be the type that an engineer will be called upon to solve. The economy considerations of engineering problems can be presented as something of a shock to his vital concern with physical solutions. If Engineering Economy is taught in a challenging manner, the students' curiosity should be aroused to learn more of the broader problems such as might be presented in Principles of Economics. Then when a student hears a discussion of taxation he appreciates how the proposed change in taxation will affect the decisions of an individual business. To the author, it appears vital that engineering colleges require a course in Engineering Economy that will provide the introduction to the economy problems and business vocabulary described above. As a very minimum plan of action, engineering educators should instigate a thorough study of the optimum arrangement for introducing engineering students to business practice and the principles of economics.

Variations and Innovations

Some interesting work is being accomplished by institutions that are attempting to integrate the teaching of Economics and Engineering Economy. However engineering educators will have to experiment even more if we want to uphold the engineer's reputation for willingness to engage in practical research in comparison with the reputation of our cousins the economists. This past year they published a report of their committee on The Teaching of Undergraduate Economics clearly emphasizing the need for improving the teaching of their subject and indicating a genuine willingness to completely reorient their program.

Typical of this willingness to try new methods is this statement of the Sub-Committee on the Study of Economics in Schools of Business: "We believe that conventional economic theory courses are not well-suited to a business student. He has no obvious interest in or motivation toward such courses. Therefore, to teach the considerable amount of economic theory which a business student should learn, a device must be found for relating the subject to his interests and objectives. This we believe can be done by centering the study around the business enterprise." They have several recommendations that would appeal to engineering students at least as much as to students of business: "(1) Analytical methods should be emphasized, as against descriptive, legalistic, approaches. The ultimate objective is to teach students to think intelligently about the problems they face. They can and usually must learn most of the facts of an individual business or industry, on the job, and (2) Historical studies should not be neglected. . . . Economic history provides perspective and may enable business men to balance short-run and long-run considerations." This sub-committee went on to make the specific recommendation that the economics taught to business students include the "economics of the business enterprise," meaning the economic problems faced by an *individual* business organization.

Economists have not only been *discussing* the problem of achieving effective teaching of their subject to all types of college students, but they have been conducting classes on an experimental basis. They have also published a number of new texts that seek to approach the subject in a more interesting manner. "Business Economics, Principles and Cases" by Alt and Bradford, "The American Economic System" by Newbury, and "Managerial Economics" by Joel Dean should be reviewed by all teachers of Engineering Economy.

This past year has also witnessed an increased interest on the part of engineering registration officials in requiring candidates for registration to demonstrate their ability to analyze engineering economy problems. Professor Matchett of Illinois Tech indicates that a section of the registration examination in Illinois is now devoted to Engineering Economy and that as a result several more engineering departments are considering requiring the subject in their curriculums. Professor R. C. Gorham of the University of Pittsburgh reports that two questions on Engineering Economy are now included in every registration exam in Pennsylvania. Professor Arthur Lesser of Stevens Institute of Technology described in some detail the situation in New York where each candidate must answer 3 out of 5 questions on the Economics of Engineering and Practice.

Employed persons are now being offered Engineering Economy and refresher work in this field. There are thousands of engineering graduates who never were exposed to the subject who are now moving into positions where they must make, or least assist in making, decisions regarding engineering economy problems. In many respects Engineering Economy is a natural subject for continuation study. One idea stressed by leading business executives replying to a questionnaire dis-

tributed by the American Economics Association, was that "many subjects can be understood and knowledge of them acquired better after graduation than before." While the principles of Engineering Economy are readily understood by undergraduates, appreciation of its usefulness should increase rapidly as an engineer gains experience.

Conclusions

The areas in which we should sell our subject are so vast that we must utilize every means at hand if we are to make appreciable progress. My own interpretation of this survey is that our biggest opportunities are:

(1) To insist that Engineering Economy is basic to engineering and should be required in the engineering curriculum.
(2) To explore the idea that it is more basic than a study of the national economy as a whole, and should be presented prior to general economics. This recommendation *does not* mean the elimination of economics, but it does suggest that economics can best be learned *after* the student has studied the principles by which an individual organization plans its economy and investment programs.
(3) To explore the means for integrating Engineering Economy, or at least coordinating it, with the teaching of economics.
(4) Te increase the availability of evening or in-service courses designed for employed engineers who want to learn more of engineering economy techniques and who are motivated to learn more of the relationship of their problems to those of the national economy. Such a venture should definitely be a cooperative venture of engineers, economists, and teachers of business principles.
(5) To increase our efforts to improve the quality of teaching.

The author wishes to thank the members of the Committee on Engineering Economy for their interest, suggestions, and counsel. The deans, administrative officers, and teachers of Engineering Economy who answered the questionnaire demonstrated a willingness to help that was far beyond what the author expected. Whatever value this paper has is primarily the result of the enthusiasm and cooperation of those who furnished the material and ideas.

In the News

The program of the second Convention of the Panamerican Union of Engineering Associations, more commonly referred to as **UPADI**, held its Convention on the Tulane University Campus August 25–30, 1952. The ASEE was represented by Dean L. J. Lassalle of Louisiana State University and Dean S. S. Steinberg of the University of Maryland. One of the speakers was W. R. Woolrich, President of the ASEE, who presented a talk on "Engineering Education in the United States."

The 30th, 31st, and 32nd basic courses in radioisotope techniques in research will be offered by the **Oak Ridge Institute of Nuclear Studies** on January 5, February 2, and March 2, 1953.

Application blanks and other information on the one-month courses may be obtained from Ralph T. Overman, Chairman, Special Training Division, Oak Ridge Institute of Nuclear Studies, P. O. Box 117, Oak Ridge, Tenn.

The Undergraduate Thesis in Chemical Engineering at M.I.T.

By ALAN S. MICHAELS

Assistant Professor of Chemical Engineering, Massachusetts Institute of Technology

I. *Educational Objectives of the Undergraduate Thesis*

The senior thesis has been an important requirement of M.I.T.'s undergraduate program for a great many years. Until October of 1943, the thesis was prerequisite to receipt of the Bachelor's degree in all fields of specialization; during the latter war-years, however, when a large percentage of the student body was in uniform and being trained for technical responsibilities in the military services, the Faculty voted to permit substitution of professional fourth-year subjects for the thesis. This regulation remained in effect after the end of the war, and fell under the scrutiny of the Educational Survey Committee during their deliberations in 1948–1949. The Faculty Committee on Undergraduate Policy, which came into being soon after completion of the work of the Educational Survey Committee, deliberated on this issue, and in March, 1951, reported to the Faculty that it favored a return to the thesis requirement. Only recently was this recommendation brought up before the Faculty for action; in February, 1952, it was voted to reinstitute the thesis as a formal requirement for the Bachelor's degree. During the eight-year period from 1943–1951, many departments (including Chemical Engineering) rigorously adhered to the thesis requirement, whereas others freely authorized course-substitutions. The records show that only about 62% of June, 1950, and June, 1951, graduates submitted theses, although the non-thesis graduates were largely confined to those (relatively few) departments whose administration believed the interests of the students to be better served by course-substitutions.

In presenting its motion before the Faculty, the Undergraduate Policy Committee implemented its recommendation by enumerating what it considered to be the major educational objectives of the undergraduate thesis:

"The senior project or thesis should provide the participating student an opportunity to:

1) Deal with a problem of some significance and be responsible for making decisions concerning it. Formulation of the problem to be undertaken and the devising of methods of attack should be involved.

2) Gain experience in seeking out information pertinent to the project.

3) Discipline himself to plan the use of time and facilities.

4) Integrate the various subjects of study and other prior experiences; coordinate and consolidate activities which may cross the boundaries of two or more professional fields of endeavor.

5) Get experience in the formal presentation of results including a carefully prepared written report.

6) Meet with staff members on an individual basis at a professional level.

7) Develop further his creative talents."

The committee also delineated the scope of the thesis to be "a comprehensive problem, involving not less than 9 credit units, which requires initiative, creative thought,

responsible decision and action for successful progress towards a solution." An individual problem was believed preferable, although group-projects were recognized as desirable in certain cases if the individual participants could be separately evaluated. A thesis might involve one or more of the following kinds of endeavor: (1) laboratory research, (2) design, (3) library research, (4) field investigation, (5) theoretical investigation, and (6) any other effort demanding responsibile individual student-contribution. An undergraduate thesis need not constitute an original contribution to knowledge, the committee believed, as long as it demanded creative thinking on the part of the student.

In Chemical Engineering at M.I.T., the above-mentioned objectives and scope of the undergraduate thesis have for so long dominated the educational philosophy of the department that it is difficult for most of us to see the necessity for their restatement. In essence, the guiding principle behind Chemical Engineering education, as established by W. H. Walker and W. K. Lewis, has been to prepare students to face new and unfamiliar situations with professional competence; the thesis, therefore, is but a continuation of a principle to which the undergraduate has been exposed since his first contact with Chemical Engineering as a field of specialization. As a consequence of this early training, the Chemical Engineering undergraduate is, we believe, peculiarly well adapted to undertaking an original project of more than minimal scope. The average student, therefore, tackles a thesis with neither apathy nor trepidation; the superior student looks forward to it with considerable anticipation, as a culmination and final test of his professional training. In response to this attitude, the department faculty tends to set higher-than- average standards of performance on thesis research, and to offer other-than-routine problems for undergraduate investigation. Due to this highly critical attitude of student and staff alike toward thesis research, one finds that an excellent undergraduate thesis is one of the most reliable indications of a man's technical achievement and professional promise.

II. *Administration and Direction of the Undergraduate Thesis Program*

While initiative and originality are of prime importance in the student's pursuit of his thesis objective, each man is expected to adhere to a clearly defined procedure and schedule which experience has shown to encourage orderliness in work-a-day performance and a modicum of uniformity of final product. In recent years, the Department has established a Thesis Committee, under the direction of a faculty member, and staffed by instructors and teaching assistants, whose functions are to disseminate standardized procedural information to thesis men, to handle routine administrative work (registration, attendance, etc.), and in many other ways to relieve the faculty thesis supervisors of routine tasks in order that they may concentrate on the technical problems relating to the students' thesis projects. The Thesis Committee has been a boon to both students and faculty, and has done much to prevent the chaos that might be anticipated with as many as a hundred students carrying on thesis projects simultaneously.

The M.I.T. Chemical Engineering S.B. candidate is expected to spend 15 credit hours (about 15% of his time) on a thesis in his senior year. Except in unusual circumstances, this time is spread over the two semesters, three hours being spent during the first and the remainder during the second. The first semester's work is devoted to the selection of a subject, literature survey, preparation of a time-schedule for the second semester's research program, and the writing and submission of a preliminary report. During the second semester, therefore, the student carries out his proposed program and prepares his final report.

In most instances, the first-term senior selects his thesis subject from a very extensive list of topics prepared each semester by the individual faculty members and

bound in booklet form for distribution by the Thesis Committee. Before making a final decision, a student discusses those subjects in which he is interested with the appropriate faculty members. Normally, selection of a topic is completed within the first two weeks of the semester. In some cases, a student may have particular interest in a project which is not included in the above list; it is then the responsibility of the student to find a faculty member interested in that specific field, and to "sell" him on the importance and soundness of his proposed program.

Before embarking on his individual project, the student is expected to read and study carefully the Thesis Manual. This Manual is the product of many years of effort on the part of the Department Staff, and is based to a great extent on experiences in project organization and report-writing gained at the field stations of the School of Chemical Engineering Practice. The manual outlines the format and describes the functions of various types of technical reports; offers a guide to the use of the scientific and engineering literature; and presents the philosophy and objectives of both oral and written technical dissertations. It is the concerted opinion of the Staff that the Thesis Manual is an effective instrument for establishing high performance standards and a uniform basis for student-evaluation.

Throughout his entire senior year, the student is essentially on his own regarding the organization and method of attack of his thesis problem. He is, however, obliged to submit brief, periodic progress reports, to adhere to prescribed deadlines in submission of his preliminary and final reports, and to attend weekly thesis seminars. Procurement of standard items of laboratory equipment is handled on a strict sign-out basis, the student being fully and individually responsible for such equipment issued to him. For the construction of special apparatus, the student may avail himself of the excellent facilities of the Department shop. After obtaining approval of his equipment design (seldom without major revisions arising out of conferences with the shop instructor), he can proceed to build his apparatus under the watchful eyes of the permanent shop personnel. In many instances, education in the operation of machine tools and in establishing rapport with a skilled labor force are among the most valuable experiences of a student's undergraduate career.

The thesis student is encouraged to maintain personal contact with his faculty supervisor (particularly during the orientative phases of his program), although he is under no compulsion to do so. The supervisor normally does not exert directive pressure upon the student regarding his research plans, but acts in a purely advisory capacity. Conferences of this sort present an excellent opportunity for the supervisor to appraise the resourcefulness, initiative, and articulateness of the student, and play a large part in determining the final thesis grade.

III. *Written Work*

As has been mentioned above, each student prepares a preliminary report and weekly informal progress memos, as well as the final thesis. The preliminary report (submitted and graded at the end of the first semester) contains the results of library research presented as historical background of the project, a description of proposed procedure to be employed in the experimental program, and the intended methods of interpreting data and correlating results, a time-schedule, and bibliography. In most instances, the literature survey and introduction presented in the preliminary report can be incorporated into the final thesis with but minor revision.

Weekly progress memos consist merely of copies of laboratory data sheets, annotated bibliographies, etc., to which are attached single-page summaries of the week's accomplishments. These reports serve as a guide to the thesis supervisor regarding the student's ability to cope with research problems, and as well, serve as a measure of student effort.

The final written thesis is due (by In-

stitute regulation) one week before the end of the spring term. The time spent in preparing this report varies greatly, depending upon the student's ability to adhere to his proposed schedule, and upon the importance he attaches to clarity and continuity of written expression.

It is all too difficult to convince the average engineering undergraduate that evidence of care and thought in the preparation of reports plays a major role in the evaluation of technical competence. The thesis supervisor, therefore, has an obligation to drive this point home to his students; he must encourage them to begin writing early to self-criticize and revise, to seek the criticism of others, and revise again. This process, unpleasant as it may appear to the senior, inevitably pays dividends to the man who submits to it, in terms both of thesis-quality and ultimate professional achievement.

IV. *Oral Reports*

Weak as is the average undergraduate's capacity for handling the written work, his ability for articulate oral expression is even less fully developed. An important aspect of the undergraduate thesis program is participation in faculty-supervised seminars. Groups of ten to twelve students meet weekly during the latter half of each semester of the senior year with a faculty member; twice during the year each student is required to present to his colleagues a formal report on the progress of his thesis work. These talks are discussed and criticized by the members of the group, from the point of view of both technical soundness and quality of presentation. During the early phases of the seminar program, before a standard of reference has been established, responsibility for comment and criticism devolves mainly upon the faculty member present. It is not long, however, before the spirit and objectives of the seminar become evident to the group as a whole, and student participation becomes vigorous and highly constructive. The opportunity of addressing a group several times, and of giving and receiving frank and informal criticism, has proved to be remarkably effective in the rapid development of skill in oral communication.

V. *Grading and Evaluation of the Thesis*

Undergraduate theses are evaluated by two agencies. An impartial faculty member reviews and grades it in terms of apparent technical soundness and "salesmanship" in presentation. The thesis supervisor evaluates not only the report, but also its author, and his overall treatment of his project. The final grade is awarded on the basis of the concerted judgment of faculty reviewer and supervisor.

Failure to accomplish the ultimate goal of a thesis project is not a factor in student evaluation, unless such failure arises from negligence or ineptness on the part of the individual. As a matter of fact, relatively few undergraduates achieve their aims as set down in their preliminary project outlines. On the positive side, successful completion of a project is an indication, not necessarily of a high degree of scientific or engineering ability, but more often of soundness in judgment of the limitations of time and experience.

VI. *Some Non-Academic Justifications for the Undergraduate Thesis*

Beyond the essentially pedagogical objectives of the undergraduate thesis cited earlier in this discussion, there appear to be a number of consequences of thesis participation which have considerable impact upon the attitude of the student and the development of the post-collegiate career. The first of these is the matter of professional interest. The field of chemical engineering has become so expansive that it is impossible, in the brief span of four years, to give a student in the classroom more than the fundamentals and basic tools of the profession, and an opportunity to apply these fundamentals to more than a few industrial processes. The undergraduate thesis has thus become an instrument by which a student can examine in detail an important and unfamiliar phase of

chemical engineering; such an endeavor cannot fail to stimulate new interests, and to assist in selecting a job in an area of the field best suited to his talents and temperament. In interviewing seniors for positions, personnel men frequently use the thesis subject as a guide to the student's general interest in research or development work, and as an object for discussion during the interview. The enthusiasm and authoritativeness with which a man describes and comments upon his thesis problem is often accepted to be a good measure of his ability to handle new problems in the industrial frame.

Another important consequence of the thesis is the opportunity presented to the faculty supervisor to make a sound personal evaluation of the student. In writing a letter of recommendation regarding a student, or in replying to an inquiry about his capabilities, a staff member may justifiably be reluctant to express his frank opinion about a man with whom contact has been limited to the classroom. The thesis supervisor, however, develops a much clearer picture of the student's characteristics, and can comment intelligently, not only upon a man's intellectual capacities, but as well upon his industriousness, initiative, resourcefulness, and personality. If, indeed, an accurate appraisal of an individual contributes to the proper direction and molding of his professional career, then this aspect of the thesis program may be an important contribution to a student's ultimate success.

In summary, this discussion has attempted (1) to outline the M.I.T. Chemical Engineering Department's convictions regarding the educational value of the undergraduate thesis, (2) to describe the organization of the thesis program, and (3) to mention a few non-academic virtues of participation in formal thesis work at the undergraduate level. The conclusion is nearly inescapable that, for the development of mental and physical coordination, sound engineering judgment, and a power for coping with technical problems, the thesis far surpasses in value any classroom subject involving a comparable time expenditure. In Chemical Engineering, perhaps to a greater extent than in other scientific and engineering fields, the thesis must be considered an indispensable part of, and in a sense the consummation of, the undergraduate educational program.

In the News

Dr. Ralph A. Morgen, director of the Engineering and Industrial Experiment Station of the University of Florida, has been appointed to the staff of the Division of Mathematical, Physical and Engineering Sciences of the **National Science Foundation.** Dr. Morgen began his new duties on June 1, 1952. He is in charge of the Foundation's research support program in the engineering sciences.

Engineering Problems in the Utilization of Atomic Energy

By W. E. KELLEY

Manager, N. Y. Operations Office, Atomic Energy Commission

I am not a teacher of engineering—at least not in the formal sense—but for eight and a half years of the twenty years since my graduation as a civil engineer, my work has been in the utilization of atomic energy. By the normal limits of the "grandfather clause" that entitles me to speak on the subject of atomic engineering. Whereas we speak of using *nuclear* energy, our problems result from the behavior of the atom as an entity. We can't blame the nucleus, the protons, the neutrons, or any *part*—we are concerned with the whole. We are concerned with the radioactivity of a material, its physical and chemical characteristics, its possible toxicity, its use as a material of construction, its dust particle size.

This brings us to a fact that you as educators are facing: our problems in utilizing nuclear energy cut straight across the lines of conventional training. We use a specialist and we need him, but the big contributions come from men with solid foundation training who have understanding of related fields.

You may have noticed that in the make-up of the afternoon session the conventional headings of Electrical Engineering, Civil Engineering, Mechanical Engineering, Chemical Engineering are missing. We don't think that way in our business. We have a *problem*—it will be solved by teamwork and fundamental knowledge drawn from all fields. As a member of the parent group, a civil engineer, I see a possible return to the days when an engineer was trained in science, before "engineering" was broken into pieces for specialists. Naturally, we will need specialists, but perhaps that is for the graduate student. I would like to have a few men in my group who have been given four years training in science and its relation to engineering problems; they would be our project leaders of tomorrow.

The other day Dr. J. R. Oppenheimer, one of the world's great physicists, told your ASEE national steering committee on atomic energy that he would like to see a few oustanding young engineers spend one or two years on basic science problems. Here is proof of our judgment—a physicist wants engineers to be trained as scientists; I want scientists trained as engineers. What we both want is a man with two heads—one head trained as a scientist, and the other head trained as an engineer. The nearer we get to that ideal, the more the graduating product will contribute to atomic energy development.

Need Men with Ideas

You will hear this afternoon of some of the major engineering problems facing us in the development of atomic science, and you will see that although we talk of *problems* we are really talking of our need for *men with ideas!*

We now have 65,000 people working directly on the development of atomic science and the production of our materials and devices. Of those, 6445 are engineers used as engineers. We need more, as you can see by reading the want ads. Our contractors—duPont, Westinghouse, General Electric, Western Electric, Car-

bide and Carbon—all need men with ideas, the kinds of ideas that stem from good training in fundamentals.

In our business, the big contributions come from knowledge of the basic behavior of matter and materials, not from a superficial knowledge of fundamentals buried under a veneer of modern gadgetry. The engineer with a knowledge of items in the catalogue has a minor role in our work. He is supervised by an engineer who knows well the fundamentals that are now but briefly covered in the conventional engineers' undergraduate "college physics" course.

As civil and mechanical engineers we find that our detailed knowledge of the behavior of steel is interesting, but not very helpful if our new structure is to be built of beryllium or zirconium or some other exotic material. We become of more use than the catalogue engineer if we can plan intelligently a program of research and development that will expedite our training in the use of the new material in question.

A man trained in designing water pumps may or may not be of use to us in designing a pump for liquid sodium or elemental fluorine. If he really understands fundamentals, he can help us.

Problems That Face Us

Without encroaching on the afternoon's program, here are a few interesting problems that face us. They're *problems*—not problems in Mechanical, Electrical, or Chemical Engineering.

In our business there is a lot to learn about the design of processes in which the volume of off gases, waste liquids and sludges is kept to a minimum. Every cubic foot per minute of waste gas may require $5 initial investment for air cleaning equipment. The problem is compounded by the difficulty of maintaining the air cleaning equipment and the disposal of removed particulate matter, sometimes toxic and usually radioactive.

Batch processing of hazardous materials should be replaced wherever possible by continuous processing which inherently lends itself to hazard control. The process that *"can't"* be made continuous just hasn't had enough engineering.

We must learn more about the removal of trace amounts of radioactive materials from liquid effluents, because of health reasons and because of the value of our products.

Portable radiation detection instruments are now well into the production phase, but they are not sufficiently versatile; they are too expensive and too delicate. They need engineering!

The mechanics by which radioactive ground contamination is transported must be better understood, both as regards vertical and horizontal transport. The phenomena associated with the adsorption of trace materials on soils must be put into quantitative form.

A whole complex of engineering tasks will be encountered in the operation of nuclear energized aircraft. In outline it's simple; a nuclear unit will power an aircraft engine. But, let's consider the matter, excluding the purely nuclear part of the design of the power reactor. Considerable weight and volume of shielding will be required on the aircraft and in service buildings on the ground; remote handling equipment will be required; special equipment to move shield doors will be needed. The design of the aircraft itself will be a new aeronautical engineering problem when the weight-to-lift ratio is considered. The heat exchanger equipment will involve materials which are radioactive or which are exposed to radioactivity. All in all, here is a fertile field for imaginative engineering.

New Engineering Designs Required

In the industrial utilization of the radioactive properties of fission products new engineering designs will be required. New remote handling equipment and master-slave servo mechanisms will be needed. Television will be economically employed.

Metallurgical problems are numerous. The operation of nuclear reactors at high temperature will require new metals and ceramics. Radiation in nuclear powered equipment can induce changes in materials. A material used in a reactor structure may either change into something else or have radically different characteristics. Electrical and thermal resistivities, elongations, corrosion properties, and structural stabilities are a few of the properties affected.

Monitoring and investigating the radiation associated with machines used in nuclear operations requires specialized electronic equipment to measure short time intervals (perhaps a hundredth of a millionth of a second) or to differentiate energy pulses initiated by different types of radiation. Equipment must be designed to do all these things and to operate with high sensitivity and with good stability.

The design and construction of machines such as the Brookhaven cosmotron requires, besides a high amperage pulsed voltage, which is accurately controlled, the fabrication of a doughnut-shaped metal vacuum chamber about 75 feet in diameter with apparently opposing requirements:

(*a*) thin walls, but with high mechanical strength, which disturb as little as possible the magnetic flux pattern.

(*b*) low operating pressure (5×10^{-6} mm. Hg or less) but as large a volume as possible in the horizontal and vertical magnet aperture.

In the less glamorous but highly important field of mining we need engineering help. Diamond drilling is used in finding most of our deposits. Drilling costs are rising, and we would like to know how to drill better holes, cheaper and faster—and where to drill them! !

As you can see from these few examples I have selected our problems cut across almost all engineering fields. Their solutions depend on getting well-trained engineers with good backgrounds of science to work on them.

We need the help of competent engineers who are on the staffs of engineering schools and interested in research. It is my opinion that more engineers should maintain contact with research men to sharpen their appreciation of new discoveries and to help translate the new things into parts of our everday life.

The Atomic Energy Commission assists in maintaining this contact by supporting work such as the Oak Ridge Institute of Nuclear Studies summer symposium on nuclear engineering education. During the last part of August and first week in September, within the limitations of housing available, they will welcome engineers interested in learning about our business. The only expenses will be those of self-support, with no charge for the training. This is only one example of engineering training having AEC support.

Statistics

I have some statistics on engineering employment on our program that may interest you. They bear out my thesis that there is no such thing as an atomic engineer. These figures are as of Jan. 1, 1951 and have since increased considerably. These men are engineers employed as engineers:

345	Civil
2	Agricultural
15	Highway
160	Safety
15	Marine Engineers and Naval Architects
50	Sanitary and Public Health
350	Structural and Architectural
355	Industrial and Administrative
1030	Chemical and Ceramics
1540	Electrical and Radio
1770	Mechanical
100	Heating and Ventilating
40	Refrigeration and Air Conditioning
105	Automotive
25	Aeronautical
105	Mining and Metallurgical
8	Petroleum and Geological
440	Engineers (Listing more than one major field)

This should dispel the idea that there is but small place in atomic energy work for the man without training in nuclear science. Today, the converse is true. Opportunities exist in the normal specialties —with top positions open to the man who can straddle more than one field.

It is you—the engineering educators—who must see to it that graduates are equipped to exploit knowledge of the atom just as engineers before them have beaten into useful shape the other great discoveries of science.

College Notes

The Department of Meteorology of **New York University's** College of Engineering has been redesignated the Department of Meteorology and Oceanography. Formal curricula leading to the master's and doctor's degrees became effective at the opening of the academic year in September.

Laurens Troost, whose achievements as a naval architect in The Netherlands have won him international recognition, will become professor and head of the Department of Naval Architecture and Marine Engineering at the **Massachusetts Institute of Technology** this autumn.

Jesse W. Mason, Dean of Engineering at the **Georgia Institute of Technology**, was granted a year's leave-of-absence effective September 1, 1952, in order to participate in the Educator in Industry Program of the E. I. du Pont de Nemours & Co., Wilmington, Del. Dr. Mason was one of the first educators to be selected by E. I. du Pont de Nemours & Co. for this new program of cooperative exchange of educators with that industry, and was chosen because of his outstanding reputation in the field of chemical engineering.

Dean William C. White, Director of the Day Colleges at **Northeastern University**, has been named Vice President of the University. He will assume his new duties on January 1, 1953. Starting at Northeastern in 1926 as an instructor, Dr. White rose in the academic ranks serving as assistant professor, associate professor, Dean of Engineering, and Director of the Day Colleges. He is at present Vice President in charge of instructional division activities of the American Society for Engineering Education.

Elmer R. Queer, professor of engineering research and assistant director of the Engineering Experiment Station at the **Pennsylvania State College**, has been appointed director of the department of engineering research and Paul Ebaugh, professor of engineering research, has been named assistant director of the department. In announcing the appointments, Dr. Milton S. Eisenhower, president of the College, explained that the Trustees had also approved the changing of the name of the Engineering Experiment Station to the department of engineering research. The new name, Dr. Eric A. Walker, dean of the School of Engineering and Vice President, A.S.E.E., explains, more clearly conveys the research and development functions of the department while the term, "Experiment Station," when adopted, indicated a test station. The department today does little testing.

Aeronautical Engineers, 1952 Supply and Demand

By K. D. WOOD

Professor and Head, Aeronautical Engineering Department, University of Colorado

Summary

The following article presents what is believed to be an accurate estimate, based on current questionnaires, of the supply of aeronautical engineering graduates in 1952 and the corresponding demand by the aircraft industry and supporting civilian laboratories.

In brief, the study shows that the demand exceeds the supply by a factor of about three. It also shows that the shortage will get worse for at least three years.

It is suggested that a scholarship program sponsored by the Air Force, Navy, and/or the Aircraft Industry is essential to the national defense if engineering education is to be kept on a voluntary basis.

Procedure for Survey of Schools

The simple questionnaire shown in Fig. 1 was sent to fifty schools giving degrees in aeronautical engineering (or aeronautical options in mechanical engineering) in

AERONAUTICAL ENGINEERING ENROLLMENT SURVEY
FEBRUARY 1952

			Estimated No. in R.O.T.C.
Graduates in calendar year 1951:	M.S.....	B.S.....	.....
Expected graduates in calendar year 1952:	M.S.....	B.S.....	.....
Possible graduates in calendar year 1953 (Junior students now enrolled):.....			.....
Possible graduates in calendar year 1954 (Soph. students now enrolled):			.....
Possible graduates in calendar year 1955 (Fresh. students now enrolled):.....			.....

Signed,

What R.O.T.C.
Army.....
A.F.....
Navy.....

( ) Check here if you wish identity of institution not revealed except in statistical summary.

For the Dept. Head or Chairman,
Aeronautical Engineering or
Prof. in Charge of Aeronautics.

..... (Institution)

..... (Address)

FIG. 1. Questionnaire sent out.

TABLE 1

AERONAUTICAL ENGINEERING ENROLLMENT SURVEY DATA, SPRING 1952

Code No.	Basis	Org.	Students reported, class of					Non-ROTC students, class of			
			'51	'52	'53	'54	'55	'52	'53	'54	'55
1	52	D	8	5	17	26	39	0	19	6e	9e
2	1	D	17	12	13	13	15e	10e	10e	6e	7e
3	52	M	27	28	21	30	28	25e	20e	13e	15e
4	0	M	15	12e	11e	15e	17e	10e	7e	7e	8e
5	52	D	24	19	18	13	35	15	12	7	18
6	52	D	13	10	5	5	6	10	5	4	6
7	52	D	12	12	7	11e	12e	6	3	5e	6e
8	52	D	50	35	25	33	68	13e	12e	8e	0e
9	52	D	41	30	26	33	49	15	13	0	0
10	52	D	18	12	10	15	20	12	10	15	10e
11	52	D	82	69	45	50	50	49	25	25	25
12	1	D	14	15	20	33	36e	14e	16e	17e	18e
13	52	D	4	10	17	18	33	8	11	9e	17e
14	52	M	0	3	4	5	5	2	2	3	3
15	52	D	25	8	5	12	12	6	2	3	2
16	52	D	12	14	19	20	83	13	14	7	21
17	52	D	50	37	38	24	0	25	17	0	0
18	52	M	14	12	10e	11e	12e	12	10e	8e	6e
19	52	D	70	25	23	18	25	30	20	9	12
20	52	D	20	18	10	17	4	16	9	13	2e
21	52	D	8	2	8	16	12	2	6	11	7
22	52	D	8	6	6	7e	8e	6	6	3e	4e
23	52	D	24	15	19	23	34	13	14e	12e	17e
24	52	D	3	6	2	13	15e	2	1	1	7e
25	52	M	14	6	9	12	27	5	4	5	7
26	52	M	3	3	1	2	8	0	0	0	0
27	52	D	10	10	10	12	14	8	9	10	9
28	52	M	4	4	7	10	26	4	5	10	26
29	52	D	44	35	15	10	17	35	15	10	17
30	52	D	48	30	30	30	33e	27e	24e	15e	17e
31	1	D	12	6	6e	12e	14e	5e	5e	6e	7e
32	52	D	68	55	48	38	43e	51	48	2	21e
33	1	M	15	15	15e	17e	20e	13e	10e	8e	10e
34	52	D	22	18	17	12	10	14	14	9	5e
35	52	D	39	27	15	22	23	23	9	14	15
36	52	D	18	18	12	16	24	17e	10e	8e	12e
37	52	D	9	6	7	8	22	6	5	5	14
38	52	M	10	8	7	7	8e	5	2	3e	4e
39	1	M	9	8e	7e	9e	9e	6e	5e	4e	4e
40	52	M	13	22	13	10	22	19	10	5	6
41	0	D	36e	32e	30e	36e	40e	28e	24e	18e	20e
42	52	D	12	19	31	23	30	10e	16e	12e	15e
43	1	D	25	30	48	58	64e	0	0	0	0
44	52	M	3	1	5	10	10	1	0	2	5e
45	52	D	8	7	8	15	21	0	0	0	10e
46	1	M	7	10	8e	9e	10e	8e	6e	4e	5e
47	1	D	27	18	20	25	28e	16e	16e	12e	14e
48	52	M	4	8	4	8	10	8	1	4	2
49	52	D	27	18	16	19	50	13	10	12	25e
50	1	D	8	15	7	8e	10e	12e	5e	4e	5e
Totals			1052	850	765	899	1211	626	492	369	459
Probable Av. Grads			21	17	14	14	18				

Abbreviations—Basis: 52, 1, 0—Questionnaire returned, spring of 1952, 51, 50 respectively. Org.: D = separate dept., M = option in ME. Data: e = estimated.

February of 1952. The list of schools surveyed is intended to be comprehensive, in that it includes ALL schools in the U.S. accredited in *any* branch of engineering which give such instruction whether or not they are accredited in aeronautical engineering. The totals of the list, therefore, represent nearly the total supply of aeronautical engineering manpower available in the United States (some technical institute trainees are also available).

Replies were received this spring from 78% of the schools solicited, the remaining figures having been estimated from a similar survey last year. A summary of the results is presented in Table 1 and the school identification, where authorized by the person replying, is given in Table 2. A summary of the results was sent to each participating school about March 11, 1952.

Procedure for Survey of Demand

Demand was estimated by interviewing the company interviewers who visited the University of Colorado in 1952 prior to April 15, and multiplying the stated employment goal of each company by the ratio of the published (1) total industrial back-log to the back-log of the companies interviewed. For example, the employment goal of six large manufacturers which hold 47% of the national back-log is 2300 additions to their engineering employment. If these companies are typical, the national goal of the aircraft manufacturers for 1952 is 5000. Preliminary figures sent out March 11 to the participating schools, and based on a smaller sample, yielded an estimate of 6000 for 1952 and a possible relaxation of demand if these goals were obtained. The figure 5000 is based on a larger sample. Government Laboratory figures are more difficult to estimate, but using figures given in Ref. 1, p. 49 on total employment of engineers in government laboratories and assuming that their ratio of demand to employment is at least as great as in the industry (it is believed to be greater), the demand in government laboratories is estimated at 2000. It is thus evident that the aircraft industry and supporting government laboratories would hire 7000 engineers this year if they could. Of these 7000, about 27% (a figure supplied by Prof. F. S. Eastman, University of Washington) or 2000 would be B.S. Aero. E. graduates *if available.*

Discussion of Results

Fig. 2 is a plot showing the number of students in each class at each of the schools surveyed in the spring of 1952 with median and average figures given for the total number of students now enrolled. The probable average civilian graduating class for the next 3 years, based on a conservative attrition rate of 10% per year, is also shown. This picture represents a continuation of a downward trend in engineering graduates which has existed since 1950. One explanation is the small birth rate 20 years before, but this is a relatively minor factor. Another is the running out of the "G. I. Bill" for college

TABLE 2

SCHOOL IDENTIFICATION, WHERE AUTHORIZED

1. Ala. Poly., Auburn
2. U. of Ala., University
3. U. of Calif., Berkeley
4. U. of South. Calif., L.A.
5. U. of Colo., Boulder
8. Georgia Tech., Atlanta
10. Ind. Tech., Ft. Wayne
12. Notre Dame
14. U. of Iowa, Iowa City
15. U. of Kansas, Lawrence
16. U. of Wichita
17. Mass. Inst. Tech.
19. U. of Michigan
25. N. C. State, Raleigh
31. Syracuse U.
33. Case Inst., Cleveland
34. U. of Cincinnati
36. U. of Okla., Norman
37. U. of Tulsa
38. Oregon State Col.
39. Drexel Inst., Phila.
41. Penn. State Col.
42. U. of Texas, Austin
43. Texas A. & M.
45. Utah A. & M., Logan
46. U. of Utah, Salt Lake
47. Va. Poly., Blacksburg
49. U. of Wash., Seattle
50. U. of W. Va.

students. It is also possible that the large number of boys who have enlisted in the armed services recently may be partly in anticipation of a post-Korea "G.I. Bill" as well as avoidance of the draft.

A combined picture of supply and demand is shown in Fig. 3. The heaviest line labeled "present students" is the total from all schools replying and is consistent with the Aeronautical Engineering enrollment figures in Ref. 2. The number of these who will probably graduate is also estimated and labeled "estimated graduate 10% attrition." The figure of 10% per year is conservative for normal times, the average of engineering schools over the United States being somewhat larger, but the lower figure is believed to be justified because of the unusual pressure on the students due to draft boards and other factors.

The number of present students without R.O.T.C. commitments, based on the questionnaires returned, is also shown in Fig. 3; and if the same percentage of attrition is applied to the present students without R.O.T.C. commitments as to all students, the lowest line gives the estimated civilian graduates. The line in Fig. 3 labeled "probable supply" takes account of the possibility that 80% of the officers called to active duty will be released after two years service, in accordance with their present agreements. But it is, of course, within the authority of the military services to make such service either longer or shorter, depending upon the international situation. In any case, it is evident that not more than an average of 600 unobligated aeronautical engineering graduates per year can be obtained from present schools in the United States for the coming three years, or a total of less than 2000 aeronautical engineers. The solution is not to transfer students from other branches to aeronautical engineering since the other branches are in similar short supply.

However, reference (2) shows that for *every* aeronautical engineering student registered in E.C.P.D. accredited schools, there are about 9 M.E.'s, 8 E.E.'s, and 7 C.E.'s (a total of 37 in all other branches of engineering). If or when industrial conditions become such that substantial "conversion" of other engineering graduates to aeronautical work becomes possible, the shortage in the aeronautical field may be fairly quickly eliminated.

Concluding Remarks

The question is raised as to whether the large sums appropriated for airplane development and construction can have meaning in the light of the trend in "free enterprise" education shown in Fig. 3. Can the money be spent if there are insufficient engineers to pay it to, for the purposes for which it was appropriated?

May not the answer to the shortage of engineering college students be a scholarship program, such as has been proposed by the National Science Foundation, but limited to aircraft and other critical defense industries?

May it not be true now, as it was in World War II, that if the military services need greatly increased numbers of college trained officers, they will have to send them to college; and if they want improved airplanes, tanks, and other complicated weapons, will they have to provide college training for the necessary civilian engineers as well as the military and naval officers? Funds already appropriated may be sufficient for such a training program if they can not be spent directly for engineering development work on account of the shortage of engineers.

References

(1) *Aviation Week*, Feb. 25, 1952, p. 33.

(2) Story, Robert C., and Armsby, Henry H. "Engineering Enrollments and Degrees 1951." *The Journal of Engineering Education*, Feb. 1952. Summary table on p. 5.

An Estimate of the Success of the Five-Year Mineral Engineering Programs*

By WILLIAM B. PLANK

Head of Department of Mining and Metallurgical Engineering, Lafayette College

In addition to the diversity in the titles of curricula in the United States Schools of Mineral Engineering, there has developed recently in a few schools a lengthening of the undergraduate program from the norm of four years instruction to five or more years for the first or bachelor degree (1). In the institutions involved the lengthened program has been applied to all engineering branches.

History of the Five-Year Programs

For a number of years, there have been cooperative undergraduate engineering courses of longer than four years in a few engineering schools. Perhaps the most noted is at the University of Cincinnati which has the longest experience in this type of program, begun in 1906 under Dean Herman Schneider. The SPEE Board of Investigation and Coordination, in its 1923–29 report, lists eighteen such programs.

Since 1903 at Harvard University, the first degree in mining or metallurgy has been obtainable only after a bachelor's degree in the Arts College, and this same program was adopted at Stanford University in 1925.

At Columbia University, three years of study in the arts college are required before entering the School of Mines and Engineering where two more years are required for the first engineering degree.

T. T. Read said of the results of these programs:

"The Dean of Engineering at Harvard later characterized its policy of dropping the four-year engineering curricula as a 'costly mistake.' The effect on mineral industry registration does not seem to have been as immediately serious at Stanford as at Columbia, but eventually it was. At Columbia, the effects were so severe on the whole engineering school that requirements were progressively so modified that an adequately prepared student can now obtain a B.S. degree in an engineering field in four years (the degree is Bachelor of Science) and the engineer degree in five. Even with this liberalization the mineral industry undergraduate registration has never recovered from the blow dealt it, and the major interest of the mining and metallurgical department has become graduate work" (2).

Ohio State University instituted its five-year engineering programs in 1945, at the conclusion of which it is possible for some students to attain the Master of Science in addition to the Bachelor engineering degree. The 1951 class was the first to graduate under these programs.

The University of Minnesota began its five-year program in 1946 which leads only to the Bachelor engineering degree.

Cornell University first applied its five-year program to Engineering Physics in 1946 and extended it to the other engineering branches, including Metallurgical Engineering, about 1948. The degree attained is Bachelor of Metallurgical Engineering.

*An address at American Society for Engineering Education, Mineral Engineering Division, East Lansing, Michigan, June 26, 1951.

The Three-Two Plan

Another type of lengthened program for engineering education is that provided by an arrangement between engineering schools and certain liberal arts colleges known as the three-two plan. By this plan the student may obtain both an A.B. and a Bachelor of engineering degree after three years work at the arts college and two years at the engineering school.

This plan has been in operation for several years at Carnegie Tech., M. I. T., and other institutions and has just recently been instituted at Columbia University and Lafayette College. The plan is not the same, however, as the ones we are discussing here because there is involved the registration in two different colleges or universities which may be considered similar to post-graduate work.

This plan has much to be said in its favor and it should be the means of turning many good men into engineering who would otherwise go into other professions.

Objectives of Five-Year Programs

I am inclined to believe that the motives and objectives for these longer programs have been mixed, but the one most often put forward is the desire on the part of the schools involved to broaden and enrich the engineer's undergraduate education with so-called cultural subjects in order to make him a better citizen and, in a fuller sense, to enable him to become a better engineer.

The SPEE Committee on "Aims and Scope of Engineering Curricula," of which Dean H. P. Hammond was chairman, in its report in the *Journal of Engineering Education* for March 1940, outlined its recommendations on this matter as follows:

"First—broadening of the base of engineering education, now in process, should be continued. Its roots should extend more deeply into the social sciences and humanities as well as into the physical sciences in order to sustain a rounded educational growth which will continue into professional life. Two stems are thus implied in the undergraduate curriculum which we have designated as (1) the scientific-technological and (2) the humanistic-social. Each of these should be organized in an articulated sequence of subject matter and disciplines designed to lead to definite educational objectives."

The Committee recommends, however, that the way to achieve these objectives is not to lengthen the program but rather to "require greater efficiency in the use of the student's time to be gained by pruning to the essentials of a sound educational program." It concludes that "the present flexible arrangement of four-year undergraduate curricula followed by post-graduate work will better meet the needs served by engineering education than will longer undergraduate curricula of uniformly prescribed duration."

William E. Wickenden in his *Second Mile,* that superb dissertation on the philosophy of the profession of engineering, made the following comments on the question of required longer training for engineers:

"The proposal to compel all engineering students to remain six years or more in college in order to complete combined courses in liberal arts and in engineering is attractive in theory but unworkable in practice. Some young men should do so, but the majority will not. Those who do are likely to find that the advantage gained comes quite as much, or even more, from sharing the life and spirit of two divisions of education with differing ideals and traditions, as from a more extended range of studies. The advantage of breadth, so gained, must be weighed against the depth which might result from devoting the same length of time to a combination of undergraduate and post-graduate training. No combined program in arts and engineering requiring more than four years can be made compulsory in the face of the demands of industry, the attractive terms offered to four-year graduates, and the wide range of engineering responsibility; nor is it likely to succeed so long as the typical student engineer, as graduation approaches, shows so unmistakably that he is fed up for a time with formal teaching and study and craves action and experience.

"Much has happened in late years to strengthen the belief that possibilities in the mile of voluntary advancement are more hopeful than any lengthened mile of compulsory discipline. Growth in post-graduate enrollments in engineering colleges in the pre-war years was especially impressive, with the ratio of master's to bachelor's degree rising above one to ten and that of doctorates nearing one to a hundred. What was particularly noteworthy was that so many of these advanced students were pursuing interests and needs which they had discovered for themselves in their early professional experience, rather than a further discipline—however ideal—which others had imposed upon them" (3).

Dugald C. Jackson, who reviewed the trends in engineering education in 1939, concurs with Dr. Wickenden in this matter as follows:

"One solution which has been proposed, that of a general lengthening of the under graduate period by one year or more, is not adequate because the most competent and ambitious students wish to pursue graduate work and many who are not restrained by personal obligations succeed in doing so. This trend toward graduate study has been encouraged by the engineering schools and is worthy of such encouragement. Such young men as suitably follow the trend will, by their individual efforts, fill any voids of humanistic studies which are without applied content but which come into the category of desirable general knowledge. Curricula of extended undergraduate length would stop those students from securing the (for them) great advantages to be derived from graduate work; while those who can profit particularly by a lengthened undergraduate curriculum can now find a number of institutions meeting their situation. Other students may graduate in arts, with a suitable background of science, and thereafter complete a sound undergraduate engineering course in two additional years; but this procedure now seems to command less favor than it did a few years ago" (4).

Let us now examine the results of some of these programs and see how they have affected enrollment and the "Sales Value" of the graduates from them.

Effect on Enrollment

First, it is found from my detailed enrollment data that the undergraduate enrollment in mineral engineering courses has fallen off in three of the five-year schools during the past two years, at a rate more than double the reduction in the total mineral engineering enrollment in the United States. At one institution, where the longer program has been in effect for more than thirty-five years, the undergraduate enrollment in mining and metallurgy in 1950–51 was just half what it was two years ago. During this same period, the undergraduate mineral engineering enrollment in the whole Country fell off twenty per cent.

This means that although the total group of undergraduates during these two years has become smaller, largely because of the graduation of veterans, the students in these three schools are turning to the standard four-year programs rather than to the longer programs.

Market Value of the Graduates

An even more important measure of the five-year curricula is the estimate placed by employers on the product of the longer programs compared with that of the four-year curricula.

One employer of engineers, himself a graduate from a four-year course at one of the institutions now following the five-year plan, has this to say about the plan:

"There is an impression in the minds of some people that the students have been given this extra year for a purpose, and that they should be worth more than boys from schools with the four-year course. There is nothing tangible that we can see that would justify this conclusion. We are offering the same pay to all men with bachelor degrees from all schools.

"Furthermore, these boys do not seem to be able to convince even themselves that they have obtained 25 per cent more value in their five-year course than if they had taken the usual four-year course. Unfortunately, it may be several years before they can evaluate the benefit, if any, from the extra year.

"Even graduate courses in engineering are of less value to a man than if he were to enter Industry immediately, after a four-year B.S., and take a training course in the industry.

"Just at this time, when we are feeling the effects of the misinformation from the Department of Labor over a year ago in regard to the oversupply of engineers, together with the demands of Selective Service, Industry finds itself in a very critical condition in so far as available manpower is concerned.

"Industry offers training courses that are oftentimes much more thorough and worthwhile in the early years of the graduate's employment than is the extra school work given in the fields where a man's future life is largely that of an individual in his chosen profession. Engineers obtain much better training in most companies by direct contact and mutual contribution in their development for the work ahead, than can possibly be given in the academic influence of the five-year course.

"As to who is the better judge of problems of this kind—I have found that any manufacturer is compelled to accept the judgment of the purchaser and user of his products rather than depend upon his sales and production departments for their opinions. I therefore think that those who employ the product of our engineering schools are more interested and better able to judge."

Conclusions

1. In considering the present and future scarcity of engineers as well as the projected annual national demands for 30,000, along with the smaller future enrollments that will result from the changes in population ages, the indications seem to be that the longer educational programs will become even less popular in the immediate future than they now are.

2. An examination of the curricula in three of the schools involved reveals that, although the humanistic social subjects are broadened, much more time is devoted to technological subjects than in most four-year programs.

3. The consensus of the ASEE authorities quoted in this paper clearly indicates that four years would be long enough for a great majority of engineering students. It would be better to stress post graduate work for the few who will eventually go into research, for example.

4. As another way of achieving the very laudable objectives of a lengthened educational program for engineers, especially for mineral engineers, I submit a proposal made twenty-two years ago to the AIME. This proposal was for some form of co-operation with industry whereby the four-year graduate could enter an approved industrial training course at the successful conclusion of which, with proper regulations, the engineering school might confer the professional engineering degree (5).

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Mid-Winter Meeting of Engineering Drawing Division

Time: January 29–31, 1953.
Place: University of Nebraska, Lincoln, Nebraska.

A three day session of technical programs and inspection trips which will include technical papers and panel discussions by teachers of engineering drawing and men from industry. Inspection trips will include the Elgin Watch Company and Boy's Town. Detailed programs will be mailed to members of the Engineering Drawing Division.

Developing a Combustion Laboratory

By J. H. POTTER

Professor of Mechanical Engineering, University of Illinois

SUMMARY

In mechanical engineering curricula, combustion has received less attention than it merits. This is particularly true of the experimental phases of the subject.

This paper reports upon a part of the development of a combustion laboratory at the University of Illinois. Six experiments are described in which such classic measurements as flame temperatures, flame velocities, and explosion pressures are made.

Most of the test installations were made up of components usually available as physics laboratory apparatus. This made possible a fairly wide coverage at minimum cost.

I. INTRODUCTION

Combustion has been either neglected or inadequately covered in most mechanical engineering curricula. In many courses, a brief review of combustion stoichiometry is followed by an equally short treatment of radiant heat transfer, and then attention is focused upon a largely empirical approach to the design of furnaces and combustion equipment.

Since World War II greater interest has been shown in the fundamental aspects of combustion. It is entirely possible that the development of this field may parallel that of fluid mechanics some twenty years ago as a "rediscovered" area in mechanical engineering.

At the University of Illinois two courses have been set up, one dealing primarily with fuels and furnaces, and the other slanted toward the fundamental phases of the combustion process itself. A laboratory has been built as a demonstration facility to supplement the theoretical work in this second course. Precision is not sought in the combustion experiments; the principal purpose has been to repeat classic experiments and to give the student some feeling for the order of magnitude of the quantity being measured. Such mechanical concepts as torque, inertia and acceleration are known and understood by the student. An appreciation of the properties of flames and of explosion phenomena should be equally important to the engineer.

II. EXPERIMENTAL FACILITIES

Six of the combustion laboratory experiments will be described: two on flame temperature, three on flame velocity, and one on the pressure rise accompanying a gaseous explosion. In some cases the experiments were made possible by interdepartment loans of apparatus; some of the equipment was built up from standard components normally available in a physics laboratory.

(*A*) *Flame Temperature by Spectral Line Reversal*

This technique, originally so modestly described by Fery (1),* has been widely accepted as a standard method for measuring the temperature of a luminous flame. It depends upon the assumption that thermal equilibrium exists in a flame, and that chemiluminesence is negligible. It is further assumed that Kirchhoff's law is satisfied, and that the brightness temperature of a ribbon filament lamp has,

* Numbers in parentheses refer to the bibliography at the end of the paper. Where two numbers are used, the second represents the page number.

at resonance, the true or black body temperature of the flame through which the filament is viewed.

In Fig. 1, apparatus is shown arranged for measuring the temperature of a Bunsen burner flame by the line-reversal method. A tungsten ribbon filament lamp, of the type used in amateur moving picture projectors, is indicated at the right. This lamp is energized from a six volt source and connected so that the input may be varied and measured. The shield to the left of the lamp may be omitted, although a metal sleeve with a narrow slit may be attached to the lamp to limit the height of the tungsten spectrum. The combustion chamber is made up from 3-inch pipe fittings and has openings to permit the passage of light from the lamp. The lenses "A" and "B" are arranged to bring the image of the lamp filament to a sharp focus on the slit of the spectroscope. The flame is colored with an alkali salt, usually sodium chloride or sodium hydroxide.

The salt may be introduced into the flame or into the line supplying air to the burner. In the flame itself, one may (a) spray an aqueous solution of the salt, or (b) salt crystals may be held above the burner top on a wire. The air-borne technique involves either (a) finely divided salt powder, or (b) salt ionized in an electric arc, or (c) salt vaporized in a heater. The latter method is shown in Fig. 1.

The observer sees in the spectroscope the continuous band spectrum of the tungsten lamp, upon which is superimposed the strong sodium doublet at 5890 Å and 5896 Å. If the brightness temperature of the lamp is below that of the flame, the sodium doublet appears as two bright yellow lines. These lines "reverse" or turn black when the lamp brightness temperature exceeds that of the flame. For the particular case when the flame is emitting as much energy at the 5890–96 Å wave lengths as it is absorbing from the lamp, neither the bright nor the reversed lines will be seen. At this optical balance point, the electrical input to the lamp is measured. The burner assembly is moved out of the way, and an optical pyrometer is sighted on the lamp through the lens "A". The pyrometer reading is corrected for the difference in effective wave lengths of the pyrometer screen and that of resonance radiation in the flame. The corrected brightness temperature of the lamp is then taken as the true temperature of the flame.

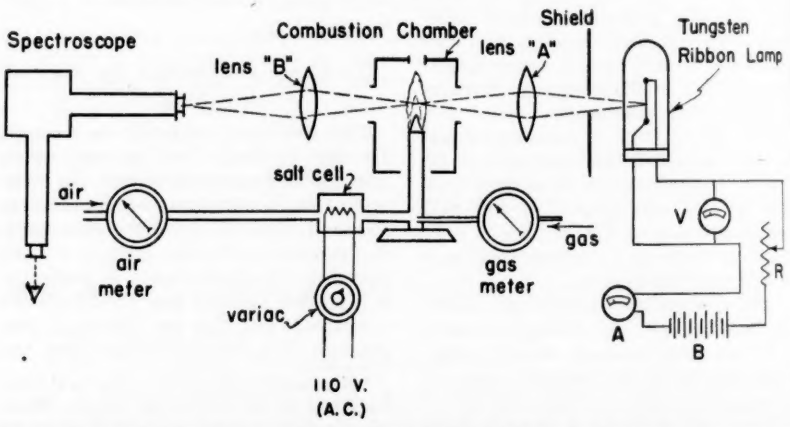

FIG. 1. Determination of Bunsen flame temperature by line reversal method. Temperature may be studied as a function of air-fuel ratio.

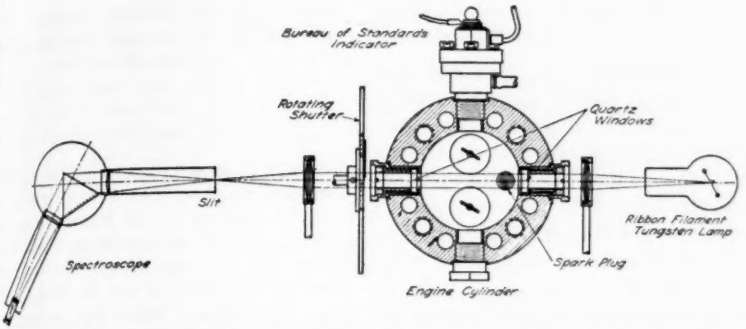

FIG. 2. Line reversal technique used to measure average temperature across diameter of cylinder of an internal combustion engine. Stroboscopic shutter relates temperature to crank angle.

The use of calibrated meters on the air and gas lines permits a study of the effect of variation of air-fuel ratio on the flame temperature. Control of the electric heater in the salt cell is effected by the variac.

(B) *Flame Temperature in an Internal Combustion Engine Cylinder by Spectral Line Reversal*

The measurement of the average flame temperature at a particular crank angle can be done by spectral line reversal. This method was successfully used by Hershey and Paton (2), and fortunately the test engine and many of the components were available for use in the combustion course.

The principal equipment is shown in Fig. 2. Because the maximum temperatures in a reciprocating gasoline engine are of the order of 4500° R., a special tungsten lamp was built with a "V" shaped filament. This device permitted a higher brightness temperature for a given filament temperature.

As the temperature varies from point to point during the engine cycle it is necessary to insert a stroboscopic shutter between the engine and the spectroscope. It may also be noted in Fig. 2 that the light path through the cylinder differs from that in the Bunsen flame of Fig. 1. The use of a parallel beam of light in the combustion chamber gives an average value of the flame temperature across this diameter. The use of the rotating shutter averages the temperature over a number of cycles so that the observer measures a temperature averaged both in time and in travel. An aqueous solution of sodium hydroxide is used, either as a finely divided spray or as a vapor from boiling liquid. In either case the sodium salt is introduced into the intake manifold.

The engine is a single cylinder water-cooled spark ignition type, suitably loaded. The particular engine used in this laboratory had a cylindrical combustion chamber which facilitated the location of the windows. Other recent installations have used constant speed units of the C. F. R. type. Quartz windows $\frac{7}{32}$ inch thick and $\frac{3}{4}$ inch in diameter are held in steel sleeves, which in turn are screwed in place in the cylinder against copper spark plug gaskets.

Pressure measurements are not essential, but a high speed Bureau of Standards indicator was part of the original test engine equipment.

Running at constant speed, the effects of air-fuel ratio and other standard engine variables may be traced in the temperature-crank angle or temperature-volume diagrams. P–V–T information may be obtained if the high speed indicator is used. Extensive chemical calculations may be made on the various equilibria involved.

(C) *Determination of Flame Velocities by the Bunsen Cone Method*

Early observers of the inner blue cone of the Bunsen burner established that it was composed of unburned gas, and that the cone shape was related to the velocity variation of the gas-oxidant mixture across the burner tube. Guoy (3) showed that combustion took place normal to the cone surface, and that the burning velocity was related to the mixture velocity by the cone angle. As the angle between the cone wall and the vertical axis of the burner varies, several measuring locations have been suggested. Noting that for laminar flow in a pipe the mean velocity is at a point 0.707 R from the centerline, this radius was used when the cone angles were measured. The flame velocity was then computed from:

$$V = U \sin \alpha$$

where: V is the burning velocity.
U is the average velocity of the gas-oxidant mixture.
α is the cone angle measured at the distance 0.707 R from the centerline of the burner.

A new approach was suggested by Garside and Culshaw (4) (5) in which the magnified image of the burner cone was traced, and the surface of revolution, divided into the rate of gas-oxidant flow, gave an overall value for the flame velocity. This method takes into account all of the variations of cone angle, and also allows for the fact that the bottom of the cone is not in contact with the top of the burner.

A modified Culshaw experiment is sketched in Fig. 3. An optical bench is used to hold the burner, lens system, and screen. These are arranged in line with a frosted lamp, and adjustments are made so that the top of the burner tube is focused on the glass screen, giving an

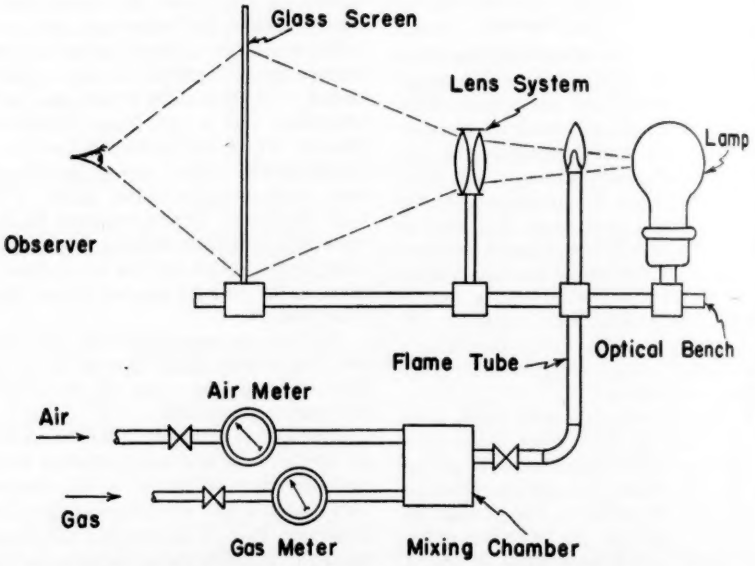

FIG. 3. Modified Garside and Culshaw experiment to determine flame velocity from Bunsen cone measurements. Air-gas ratio a controllable variable.

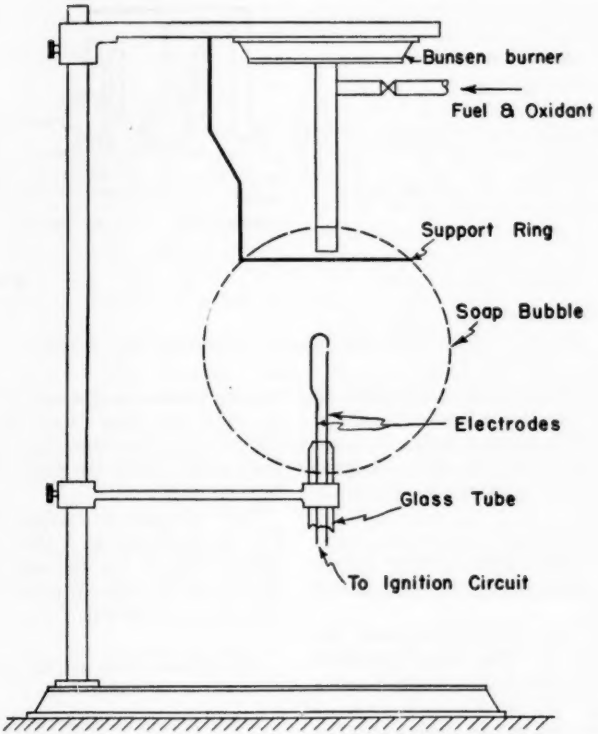

FIG. 4. Details of apparatus for blowing and supporting soap bubble in constant pressure bomb method for determining flame velocity.

image about six times as large as the tube. The lamp is turned off, and the enlarged image of the cone is traced on the glass screen. This may be done with tissue paper held against clear glass, or the glass itself may be frosted.

The tracing is divided by a number of horizontal lines and the volume of the figure of revolution swept out between each set is computed. These segmental volumes are then summed up and divided by the scale factor to obtain the actual area of the inner Bunsen cone.

Gas and air meters give a measure of the flow rate of the mixture, and the flame velocity is taken as the quotient of the flow rate by the cone area.

In this experiment a glass burner tube was used, having an internal diameter of 0.300 inches, and a length of 32 inches. No attempt was made to cool the burner tip nor to operate the combustion process at less than atmospheric pressure.

(*D*) *Flame Velocity Determination in the Isobaric Bomb*

Flame velocity may be measured by observing the rate of growth of a spherical flame front in an explosive mixture. The constant pressure bomb is well suited to this type of measurement, as only small quantities of the mixture are required. Also the mixture is initially at rest.

A widely used technique has been described by Jost (6–69) and is recounted in a number of the reports of the

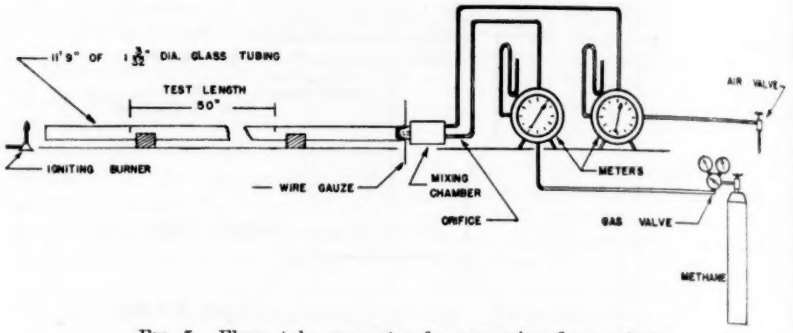

FIG. 5. Flame tube apparatus for measuring flame velocity.

N.A.C.A. It consists of introducing an explosive mixture into a soap solution and blowing a bubble about 3 inches in diameter. This can be done in such a manner as to include central electrodes within the bubble.

Ignition is designed to occur under photographic observation; a drum camera or a high speed motion picture camera may be used.

The bomb and ignition electrodes are shown in Fig. 4. The upper platform carries an inverted Bunsen burner and a support ring. The ring is made from 12 ga. steel wire and, in the plane normal to the paper, is bent to form a circle 2 inches in diameter. The lower support carries a glass tube through which the electrodes are threaded.

A soap film is drawn across the support ring by raising a dish of soap solution over the wire. The gas and oxidant are premixed in a small tank under a pressure of several inches of water. The air bleed on the Bunsen burner is sealed off, and the mixture is introduced slowly. Careful shaping of the electrodes makes it possible to blow the bubble over them. A battery and ignition coil circuit is used to ignite the charge.

A special drum camera was built for the laboratory. It consisted of a small synchronous motor directly connected to a small aluminum cylinder, the whole being enclosed in a black box equipped with a shutter and lens system. The drum camera gives a wedge shaped picture as the spherical flame front grows. From the picture dimensions and the synchronous motor speed, the flame velocity may be computed.

This technique has recently been refined (7) by substituting a thin transparent rubber balloon for the soap film. The newer method makes it possible to control moisture as a variable.

(*E*) *Flame Velocity Measured in a Long Tube*

A less refined method for measuring the velocity of a flame involves the timing of the flame front as it moves along a tube. Apparatus designed to do this is shown in Fig. 5.

Air and gas are separately metered and brought to a mixing chamber. A wire gauze screen covers the cork, connecting the tube and the mixing chamber, as a precaution against flashbacks.

In the particular test under consideration, the tube has an internal diameter of $1\frac{3}{32}$ inches. This is below the 2 inch minimum suggested by writers in this field, who point out that the tube radius affects the flame speed in the smaller sizes. For this reason the test was considered less as an experiment than as a demonstration. In the latter sense, it was especially successful as it gave the student a real feeling for the magnitude of flame velocity under atmospheric conditions.

Two types of experiments were run on the apparatus. In the first, the tube was filled with an explosive mixture, the cork was removed, and the tube ignited at the far end. In the second, a steady flow of air-gas mixture was supplied and the flame front was obliged to move against this initial velocity of the mixture. In either case, the flame front was timed between two fixed points on the tube 50 inches apart. The flame velocities were computed from these data (6–65) and from the calculated initial velocities of the mixture.

(F) *Measurement of the Pressure Rise During Isometric Combustion*

Equipment for measuring the pressure rise during isometric combustion of a gaseous mixture is shown in Fig. 6. It parallels the work done by Clerk (8) some seventy years ago. The apparatus was built up largely of spare parts. The main vessel was an old annealing pot which, when covered and inverted, constituted a bomb of 366 cubic inch capacity. Three bosses were welded to the top, and were tapped for a filling connection, spark plug, and engine indicator respectively.

Through suitable valves, the bomb was connected to a vacuum pump so that it could be emptied of the products of combustion of the previous charge. The bomb was then filled with an explosive mixture and all of the valves closed. The indicator connection was opened, and the chronometric drum mechanism set in motion. The bomb was then ignited from an induction coil circuit.

The trace on the indicator card gave a pressure-time plot of the combustion process in the bomb. As a teaching device the experiment has some interesting aspects. The students were asked to estimate the temperature rise in the isometric bomb, and from this to make a refined adiabatic calculation including variable specific heats and dissociation. The temperature arrived at by the second approximation was then used to estimate the maximum pressure attainable. The spring for the engine indicator was selected after this calculation. The esti-

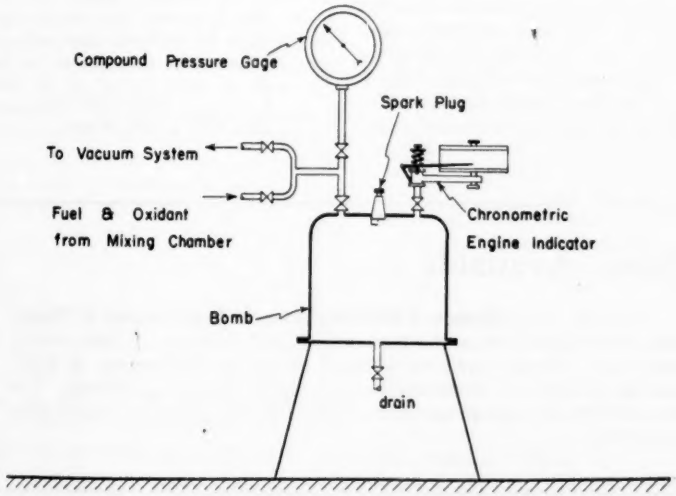

FIG. 6. Bomb equipped for measuring pressure-time relation during explosion of a gaseous mixture.

mated and measured values of the maximum pressure were compared in tabular form for several mixtures of air and hydrogen. The effect of mixture composition upon the rate of pressure rise was also noted.

III. Conclusions

This paper constitutes a progress report on the combustion laboratory. New experiments are in preparation, and several of the present techniques are being refined. The laboratory is intended as a teaching facility and is supplementary to the theoretical combustion course.

In general, the students have shown real enthusiasm for the type of work done in this laboratory. It has stimulated an interest in combustion research. Several students have later taken individual laboratory investigations in this field, and a few have written theses in the combustion area.

IV. Acknowledgments

The writer has had assistance from many students and staff members. For facilities, equipment or advice he wishes to thank Professors N. A. Parker and W. L. Hull of the Department of Mechanical Engineering, and Professor G. M. Almy of the Department of Physics. Long hours and substantial help were given by Dr. T. W. Price and Mr. R. B. Dillaway.

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Now Available . . .

Reprints of the **Report of the Committee on Improvement of Teaching** which appeared in the September, 1952 Journal of Engineering Education. Checks and orders should be sent to the Journal of Engineering Education, Northwestern University, Evanston, Illinois. The price is 10¢ per copy in quantities under 100, 05¢ per copy in quantities over 100.

Can Present Curricula in Industrial, Administrative, Management Engineering, Etc. Be Unified Under One Title?*

By WASHINGTON PLATT

Chairman, Dept. of Administrative Engineering, Syracuse University

The purpose of this paper is to define more clearly the field of usefulness covered by those Departments of Engineering called indiscriminately by such titles as Industrial, Administrative, Management Engineering, etc., and to suggest unification as to title.

It is NOT our purpose to propose a standardization of all curricula in this field any more than the curricula in Civil Engineering are now, or should be, standardized. Curricula in all branches of Engineering vary in emphasis at different universities in accordance with local opportunities and this is as it should be.

It is also NOT the purpose of this paper to attempt to draw sharp lines of distinction where no sharp lines in fact exist. In Chemical Engineering, for example, we would agree that a chemical engineer who was engaged in the design, construction or operation of equipment for carrying out industrial chemical reactions on a large scale was working in the typical field of the chemical engineer and that he was working in the field for which he was fitted by his education better than was any other kind of engineer. However, we admit freely that such activities grade imperceptibly in Chemical Engineering research into those of the pure chemist; and in construction and operation into those of the civil or mechanical engineer. If we can define the *typical fields of usefulness* the borderline cases need not worry us.

In what follows, "Industrial Engineering" will be used for the sake of brevity to cover the general field usually included under Industrial, Administrative, Management Engineering and similar titles.

Comparison with Chemical Engineering

The general development of Chemical Engineering as a well recognized field of Engineering will throw light on the present situation as to Industrial Engineering and the opportunities for overcoming our present difficulties.

About 30 years ago, David Wesson, then President of the American Institute of Chemical Engineers, stated that in the minds of many, a chemical engineer was the combination of a poor chemist with a poor engineer; and that many believed that a Chemical Engineering curriculum consisted of almost any miscellaneous mixture of a little Chemistry and a little Engineering. In my own experience when it was suggested that we hire a chemical engineer, the question would be asked, "Why don't you hire a *real* chemist?" or "Why don't you hire a *real* engineer?"

Chemical engineers were not discouraged by this general lack of understanding and appreciation. They have justified their place in the sun. They have proven that there are some activities that they can carry out better than any chemist and

* Paper presented before the Regional Meeting of the A.S.E.E., Buffalo, N. Y., October 14, 1950.

better than any other kind of engineer.

Like Chemical Engineering 30 years ago, I should say that few employers or others understand the present typical field of usefulness of Industrial Engineering. Many consider that the industrial engineer is a combination of a poor accountant with a poor engineer. They feel that the Industrial Engineering curriculum has no inherent unifying core; but consists of a miscellaneous three part mixture of engineering, personnel management and accounting.

Present Confusion in Titles

In the just mentioned ways, I am convinced that Industrial Engineering stands now just where Chemical Engineering stood 30 years ago.

In one important respect we are in a much worse position than the chemical engineer of 30 years ago. Chemical Engineering was never widely known by any other name. The chemical engineers had a big job explaining to all concerned what Chemical Engineering was, but they had only *one name* to explain. In the general field of Industrial Engineering we find several names covering exactly the same field and several other names in adjacent fields or which sound much the same.

For example, the ECPD (1948) accredits 19 curricula under the heading of Industrial Engineering. Of these, 11 use the title "Industrial Engineering"; 5, "Administrative Engineering"; while others use: "Engineering and Business Administration" (Harvard); "Business and Engineering Administration" (MIT); "Management Engineering" (RPI).

Outiside of these accredited Engineering courses we find names which sound at least superficially confusing such as Departments of "Industrial Administration" (Yale) and Colleges of "Business Administration" (Syracuse).

Under these circumstances it is not surprising that we are confused among ourselves and that we leave the public and our prospective employers even more confused.

What then is the field of usefulness of Industrial Engineering?

Industrial Engineering in Current Industry

First based upon current practices in industry. In 1947 Andrews wrote a Master's thesis on "A Study of Industrial Engineering Practices based on a Survey of Industry in the Syracuse Area" (1). If we accept the Syracuse Area as a reasonably fair sample we have here some light on what industry currently thinks Industrial Engineering is and ought to be.

The situation as found by Andrews is shown in the following table which shows what Industrial Engineering activities are practiced in current industry and under what departments.

Industrial Engineering in Current Curricula

On the other hand we have a valuable recent study by F. H. Thomas "Industrial Engineering—What Is It?" (2) showing what American Universities are currently offering under this heading. Nineteen Colleges of Engineering teach this branch of Engineering under the following titles:

Industrial Engineering—12
Administrative Engineering—3
Management Engineering—2
Business and Engineering Admin.—1
Option in other curricula—1

In deciding what should be included in Industrial Engineering curricula we need not be limited by current practices in industry. The universities should be a jump ahead of industry. They should exercise real leadership in finding useful industrial applications of the latest scientific and engineering developments.

Industrial Engineering Defined

It has been said that Engineering deals with

Materials, Methods, Men and Money
based upon Mathematics and
Physical Sciences

TABLE I

From Andrews, loc. cit.

Industrial Engineering Activities	Department to Which Assigned															
	Industrial Engineering Dept.	Production Engineering Dept.	Plant Engineering Dept.	Standards & Methods Dept. & Time Study Dept.	Production Control Dept.	Quality Control Dept.	Inspection Dept.	Planning Dept.	Wage & Rate Dept.	Safety Dept.	Personnel Dept.	Accounting & Comptroller	Cost Dept.	Other Depts., Individuals, or not specified	Total number of plants answering
A. Operator and Foreman training (formal or classroom)											6			18*	24
B. Preparation of Operation Sheets	3	1	7	12*	1			1					1	7	33
C. Methods and Motion Study	6	2	1	19*	1			1					1	6	34
D. Machine Loading	5	3	2	2	11*			3					1	6	33
E. Standard Machine Data Development	4	2	4	7*									2	6	25
F. Standard Time Study Data for Synthetic Rates	6	2	1	15*	1								2	3	30
G. Time Studies	7	2	1	19*									2	4	35
H. Actual Rate Administration	4	2		4					3		5		2	16*	36
I. Job Rating	5	2		5					4		7		2	11	36
J. Merit Rating	2	1			1				3		7		2	16*	32
K. Costs and Estimating	2	2	2	6	1			1				9	14*	5	42
L. Plant Layouts	2	2	17*	6										11	38
M. Production Control		4	1		20*			8						7	40
N. Quality Control		3	2		1	7	12*	1						8	34
O. Safety			3		1					11	13*			8	36
P. Planning and Scheduling		2	1	1	18*			7						10	39
Q. Standard Practice Bulletins	2	1	2	3							1	1		11*	21
R. Plant-wide Organization Charts	1								1		2	1		18*	23
S. Budget Control	2		1	1								15*	1	12	32

*Indicates the Department to which the activity is assigned in the greatest number of plants. 8/11/47 by DRA.

For M.E.'s, E.E.'s, C.E.'s and Ch.E.'s, the priority is in the order just given.

For Industrial Engineers the priority is:

Men, Methods, Money, Materials
based upon Mathematics,
Physical and Social Sciences

Briefly, an industrial engineer has first of all a reliable foundation in Engineering. He applies this engineering knowledge to manufacturing, or better, to the *coordination* of manufacturing.

Doctors of medicine have many specialties, but their whole medical course is

unified by their study of the human body and its interrelationships. So Industrial Engineering activities are of many kinds, but they all center around the applications of Engineering to the industrial organization, particularly to the manufacturing department. Industrial Engineering is for 9 out of 10 the Engineering of Manufacturing.

See also Goring (3).

Under typical conditions in the ideal factory the civil engineer designs and constructs the building itself, but the industrial engineer is responsible for Plant Layout including the location of machinery, working space, conveyors, storage space, etc.

The mechanical or electrical engineer is responsible for the design, construction and operation of the various pieces of mechanical or electrical equipment. However, the industrial engineer is responsible for integrating all pieces of equipment with the labor, raw material, conveyors, storage facilities, etc., into a streamlined, well-balanced, efficient, over-all manufacturing operation.

The M.E., E.E., C.E. or Ch.E. may consider principally the technical side of engineering, while the industrial engineer usually has a human being in the picture. The human factor and the dollar sign enter into most of his equations. Therein lies the chief difficulty, and also the chief glory of Industrial Engineering.

It may be said that a mechanical engineer is interested in a machine which is run by a human being; whereas an industrial engineer is interested in a human being who happens to be running a machine. It is significant that one of the typical studies of mechanical engineers is Kinematics, analyzing the motions of parts of machines, while a typical study for industrial engineers is Motion and Time Study which includes analyzing the motions of parts of human beings.

The branch of Industrial Engineering so far described concerns engineering problems which occur mostly within the four walls of a factory. Typical subjects are:

Factory Layout
Methods Engineering
Production Planning and Control
Quality Control
Motion and Time Study
Safety Engineering
Personnel Management
Employee Training

There is also a branch of engineering which is concerned with engineering surveys, top management planning, and engineering investigations of the kind made by consulting engineers for financial purposes. Problems attacked include those of plant location, industrial reorganization, industrial expansion, etc. University courses helpful in solving these problems include those in economic geography, population trends, transportation, business cycles, etc. It will be seen that many of these problems and their answers occur outside of the walls of a single factory.

This is a field of importance, but of limited numbers, compared with the enormous numbers engaged in the Engineering of Manufacturing. Those firms or companies having such activities usually assign their more mature engineers to such work, since experience and judgment are so essential. Few colleges of engineering emphasize such activities for their undergraduate curricula; though in most engineering colleges which are part of a large university, an undergraduate industrial engineer with sufficient electives or a graduate engineering student could easily prepare himself for such work by electing the proper courses in other colleges of the university.

Some few use "Industrial Engineering" for the Engineering of Manufacturing and the term "Administrative Engineering" to cover Engineering Surveys and Top Management Planning. This distinction is not generally recognized either in education or in industry. The desirability of the continued use of both titles is open to serious question.

Such surveys, planning and investigations can usually best be carried out by engineers because the engineering prob-

lems are often of fundamental importance, and are apt to be overlooked by those without an engineering background. It is believed that these activities can properly be included under the general title of "Industrial Engineering" along with the activities more intimately connected with Manufacturing proper. This practice is followed in the School of Engineering at Columbia University, for example, where considerable emphasis is put upon Engineering Surveys, yet this activity is included under the general title of Industrial Engineering. Where surveys and industrial investigations are concerned primarily with questions of accounting, law or finance, the field is not properly engineering at all. It should not have a quasi engineering title, but should be called frankly Business Administration.

Selection of a Title

In the selection of a title every consideration of this field known to the present author gives preference to Industrial Engineering over other possible names. For example, ECPD uses this general title for the Division to be represented on its General Council. The engineering society in this field is known as the American Institute of Industrial Engineers. The excellent article "What's New in Industrial Engineering?" (4) states that out of 28 Universities listed as giving degrees in this general field, 13 gave the degree in Industrial Engineering with the nearest competitor 4 in Engineering and Business Administration.

Several corporations such as Bethlehem Steel, Eastman Kodak, etc., have Departments of Industrial Engineering. Very few designate their departments in this field as Management or Administrative Engineering or one of the similar titles found in Universities for Departments in this area.

Rightly or wrongly, Industrial Engineering is preferred by many in industry as having a down-to-earth flavor, whereas Administrative Engineering suggests the "high hat" attitude. Some representatives of industry have feared that administrative engineers might object to getting their hands dirty. It is a fact that in Engineering Placement one receives ten requests for industrial engineers to every one for an administrative or management engineer.

The title adopted for this department of engineering should be short and simple, corresponding to the short, direct titles for Civil, Mechanical, Electrical Engineering, etc. Such simple titles are preferable to "Business and Engineering Administration," for example. In general, "Administration" or "Administrative" are undesirable words in the title. Titles containing these words are often confused with those of colleges of Business Administration.

The preponderance is therefore found to be overwhelmingly in favor of the term "Industrial Engineering." Is it not time that institutions using other titles did their part to eliminate the present confusion by conforming to the prevailing title, especially when the prevailing title is a pretty good one, however examined?

Conclusions

1. Those engineering activities now entitled Industrial, Administrative, Management Engineering, Business and Engineering Administration, etc., have a real unity and a definite field of usefulness in that all of these activities center around the industrial organization.

2. Such Engineering is well described as "Industrial Engineering"; that is, the application of engineering principles to industry, apart from those activities already covered by Civil, Mechanical, Electrical, and Chemical Engineering proper. In most of its aspects Industrial Engineering is the Engineering of Manufacturing. In its larger meaning it is the Engineering of the Industrial Organization as a whole.

3. Industrial Engineering problems usually emphasize Men and Money more than do other departments of Engineering. This adds to the difficulty and to the importance of this field. It is the distinction of Industrial Engineering that it specializes in the Human Side of Engineering.

4. One of the principal obstacles to a better understanding of this field has been the diversity of names by which the same field of Engineering has been called, and the border line curricula with superficially similar names which are not engineering at all, but which add to the confusion by their similarity of wording.

Recommendations

1. That the Department of Engineering concerned with the applications of Engineering to industrial concerns as a whole, and especially to the coordination of manufacturing with emphasis on the human and financial sides of Engineering, be unified under the title *Industrial Engineering.*

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College Notes

A distinguished career as a teacher of engineering at the **Catholic University of America** ended for Thomas J. MacKavanagh, head of the Department of Electrical Engineering since 1918, upon his retirement on August 31st. Joseph C. Michalowiez, who got his degree of bachelor of electrical engineering at Catholic University in 1940, and has been on the teaching staff of the department since 1942, has been named acting head of the department.

The Bureau of Audio-Visual Instruction of the **State University of Iowa** has just released a revised edition of two of its most important sound films: "Motion Study Principles" and "Motion Study Applications."

These films were originally produced by the Bureau of Audio-Visual Instruction under the direction of Professor Ralph M. Barnes, and have had such wide acceptance that a revised edition has been prepared. The entire film has been retaken and the new prints are now available on a rental or sales basis by the State University of Iowa, Bureau of Audio-Visual Instruction, Iowa City, Iowa.

Research and study on structural problems in the development of ocean-spanning rockets and supersonic aircraft will be centralized for the first time at **Columbia University's** new Engineering Center. The projected Aeronautical Structures Laboratory, through which the centralization will be achieved, will have a three-fold mission: conductive research, providing trained graduates in a new and fast-developing field, and providing a clearing-house for research information on aeronautical structures. The laboratory will also investigate structural problems stemming from such new techniques as refueling while airborne, the use of "parasite" aircraft, and the carrying of radioactive material or equipment.

Is the Traditional Program in College Mathematics Adequate for the Training of Prospective Engineers and Scientists?

By KENNETH L. NOBLE

Assistant Professor of Mathematics, University of Denver

At the present time, the college program of mathematical training for future engineers and scientists faces a double problem. It has the problem of extending its course work downward to complement the increasingly poor mathematical background of the high-school graduate as well as the need of enlarging its offerings to meet demands for the mathematics necessary in increasingly complex fields of science.

The quality and quantity of the high-school preparation in mathematics of students who intend to become engineers or scientists has long been a problem to college teachers of mathematics. Some students come to college with a good mathematical background, but many are poorly or inadequately prepared.

College teachers tend to place the blame for this unsatisfactory background on the high school. Is this a fair and reasonable criticism of most high schools? Another tendency is to feel that the student should not enter college to be trained as an engineer or scientist until he has the proper mathematical background. Is this attitude fair and reasonable in the case of many students?

In order to suggest an answer to these questions, suppose we consider some phases of the high-school situation at present, taking a large, over-all point of view.

Inasmuch as only a small portion of high-school graduates enter college to be trained as engineers or scientists, the preparation of students for the study of college mathematics is not a major objective in most high schools.

Some large high schools are able to offer enough work in mathematics to give an excellent background for college courses of study. The Denver high schools,[1] for example, offer four semesters of algebra, two of plane geometry, one of solid geometry, one of trigonometry and one of mathematical analysis.

Meager Offerings in Math

Since most of our high schools are small, their offerings in mathematics are meager and many students simply do not have the opportunity to acquire a good background. The small high school cannot afford, in the light of the number of students involved, an extended course of study in mathematics.

Although the guidance function of high schools is constantly improving, many students who wish to become engineers or scientists do not understand what abilities are needed for success in scientific work or what courses they should take in high school to prepare for that work. Also

[1] Denver Public Schools, *The Mathematical Program of the Denver Public Schools*, 1951.

students who could become good engineers or scientists may never be directed toward those fields.

In an address before the Committee on Secondary Schools of the American Society for Engineering Education, Evans, of the University of Maine, discussed the problem of high-school preparation:

> . . . representatives of prominent secondary schools told us that there was little hope that, by and large, our students would be better prepared in the future. . . . We shall see mathematics more interesting than effective, we shall see physics and chemistry more descriptive than mathematical, we shall see more time devoted to vocational subjects rather than to disciplinary drill in and mastery of those subjects which are more basic to a college education. . . . if a student knew when he entered as a [high-school] freshman that four years later he would be attempting to gain admission to an engineering school, he could do much to bolster his preparation. On the other hand, if many students who enter high school with definite plans to enter an engineering school knew more about the intellectual requirements necessary to successfully pursue an engineering education . . . they might wisely elect to try some other field. . . . Since the percentage of high-school graduates who go on to technical schools is very small, say between one and two per cent of the total, and perhaps ten or fifteen per cent of the total going to institutions of higher learning, we can hardly expect even the larger school to carry special facilities for this group.[2]

Percentage Enrollments

It is interesting to consider actual percentage enrollments in high-school courses which could contribute to a good mathematical background. Table 1 shows us that about one in six high-school students is enrolled in elementary algebra, one in nineteen in intermediate algebra, one in twelve in plane geometry, one in seventy in solid geometry, one in sixty in trigonometry, one in seventeen in chemistry and one in twenty-five in physics.

[2] W. S. Evans, "Let's Be a High School Freshman," *The Journal of Engineering Education*, **41**: 249, December, 1950.

TABLE 1

PERCENTAGE OF PUPILS ENROLLED IN CERTAIN HIGH-SCHOOL SUBJECTS IN ALL PUBLIC SECONDARY DAY SCHOOLS IN THE UNITED STATES, 1948–1949*

Subject	Percentage enrollment**
Elementary algebra	15.1
Intermediate algebra	5.4
Plane geometry	8.7
Solid geometry	1.4
Trigonometry	1.6
Chemistry	5.9
Physics	4.0

* Adapted from John R. Mayor, Editor, "What Is Going On in Your School," *The Mathematics Teacher*, **44**: 413, October, 1951.

** Based on a total enrollment of 6,907,833 pupils.

It may be fair and reasonable to criticize the efficiency of some high-school teaching of mathematics, but the criticism of inadequate offerings is not just. While there is much room for the improvement of guidance at the high-school level, it is not just to criticize the prospective engineer or scientist for lack of opportunity to obtain an adequate mathematical background.

College has Problem

Thus the college has the problem of bringing many freshmen up to a "state of readiness" for the usual mathematics courses which are a part of the training of engineers and scientists.

Concomitant with the small hope that freshmen entering college courses of study will have improving mathematical backgrounds is the fact that engineers and scientists need increasing amounts of ability in increasingly complex mathematical subjects.

Traditionally the future engineer or scientist has studied during the first two years at the college level the subject matter of college algebra, trigonometry, analytic geometry, differential calculus and integral calculus. In some schools,

electrical engineering students have also taken a beginning course in ordinary differential equations in the third year.

Pertinent to the need of an increasing background in mathematics, Bewley of Lehigh University states that:

> There are, however, certain electrical engineering courses which bring into play on genuine engineering problems the whole galaxy of undergraduate mathematics, and in addition point the way to the necessity for advanced study in mathematics as a necessary engineering tool. . . . The almost universally adopted undergraduate course in transients based on Heaviside's or the Laplace transform methods, require a substantial background in the theory of differential equations, gamma, error, and Bessel functions, certain theorems in algebra, Fourier series and integrals, and determinants; . . . .[3]

Bewley, in this same article, mentions other electrical engineering courses which require a knowledge of partial differential equations, operational calculus, series, boundary value problems, vector analysis, complex numbers, functions of a complex variable and others.

Along the same line, quoting Shanks of Purdue University:

> Consider the fact that a research engineer may be asked to tackle such difficult and diverse problems as the vibrations of nonlinear systems, the flow of viscous or compressible fluids, and the electromagnetic fields of complex configurations. Clearly it takes considerable mathematical maturity just to comprehend such problems.[4]

Daniels, in his book, *Mathematical Preparation for Physical Chemistry*, as early as 1928 included above calculus: ordinary and partial differential equations, infinite series, probability and various graphical methods of solving problems.

Not only must the college be able to improve the mathematical background of entering freshmen, but it must also be able to extend the training of engineering and science students beyond the usual courses in calculus.

Any solution of this problem must be considered in light of the total college curriculum for the engineering or scientific worker. For example, a feeling exists that such a student needs more training in English, social sciences and communications. The tendency is to add to, not subtract from subject matter.

Counseling Needed

Of great assistance in any solution would be the proper counseling of the high-school student. In this field the colleges could be of much help, particularly in acquainting the student with the abilities necessary for success in the engineering or scientific fields.

One possible type of solution would be the requiring of five years of training for the bachelor's degree. This would allow a two year pre-science training period followed by three years during which specialization could increase.

Another possible type of solution could be the giving of a broader course with less specialization during the four years and allow the needed specialization to come at the graduate level or through job experience after graduation.

It is realized that this problem is not universal but applies only to a portion of all college students. It probably does not apply equally to all engineering and physical science students. Nevertheless, the problem is crucial, particularly in view of maintaining a desirable reservoir of adequately trained scientific personnel.

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[3] L. V. Bewley, "Teaching Field Theory to Undergraduate Electrical Engineers," *The Journal of Engineering Education*, **40**: 532, May, 1950.

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TIMELY TIPS

Right Triangles with Integral Sides

By F. C. BRAGG

Associate Professor of Engineering Drawing and Mechanics,
Georgia Institute of Technology

(Papers submitted for TIMELY TIPS *should not exceed 3 pages of typewritten, double-spaced material, including any mathematical formulas, and should contain not more than 2 illustrations.)*

It is well known that there are certain triangles, whose sides are integral numbers, such as 3, 4, and 5, which are right triangles. However, relatively few of these many number combinations which will designate the sides of right triangles are available to the teaching profession.

To correct this situation, the attached table gives 90 such combinations of which 76 represent independent or prime relationships, while the other 14 items are multiples of the independent or prime combinations.

This table was derived as follows:

Let the three sides of a triangle be

$$A = 2k^2 + 2kn + n^2$$
$$B = 2k^2 + 2kn$$
$$C = 2kn + n^2$$

TABLE OF RIGHT TRIANGLES WITH INTEGRAL SIDES

	$n = 1$	$n = 3$	$n = 5$	$n = 7$	$n = 9$	$n = 11$	$n = 13$	$n = 15$	$n = 17$
$k = 1$	3 4 5	15 8 17	35 12 37	63 16 65	99 20 101	143 24 145	195 28 197	255 32 257	323 36 325
$k = 2$	5 12 13	21 20 29	45 28 53	77 36 85	117 44 125	165 52 173	221 60 229	285 68 293	357 76 365
$k = 3$	7 24 25	27 36 45 (9)	55 48 73	91 60 109	135 72 153 (9)	187 84 205	247 96 265	315 108 333 (9)	391 120 409
$k = 4$	9 40 41	33 56 65	65 72 97	105 88 137	153 104 185	209 120 241	273 136 305	345 152 377	425 168 457
$k = 5$	11 60 61	39 80 89	75 100 125 (25)	119 120 169	171 140 221	231 160 281	299 180 349	375 200 425 (25)	459 220 509
$k = 6$	13 84 85	45 108 117 (9)	85 132 157	133 156 205	189 180 261 (9)	253 204 325	325 228 397	405 252 477 (9)	493 276 565
$k = 7$	15 112 113	51 140 149	95 168 193	147 196 245	207 224 305	275 252 373	351 280 449	435 308 553	527 336 625
$k = 8$	17 144 145	57 176 185	105 208 233	161 240 289	225 272 353	297 304 425	377 336 505	465 368 593	561 400 689
$k = 9$	19 180 181	63 216 225 (9)	115 252 277	175 288 337	243 324 405 (9)	319 360 481	403 396 565	495 432 657 (9)	595 468 757
$k = 10$	21 220 221	69 260 269	125 300 325 (25)	189 340 389	261 380 461	341 420 541	429 460 629	525 500 725 (25)	629 540 829

with k and n any numbers greater than zero. Then the triangle will be a right triangle and, if k and n are integers, then the sides will also be integral numbers. It should be further noted, when even integral numbers are used for n, then the resultant triangles are not independent or prime.

In the table, columns represent triangles obtained by substituting for k integral values from 1 to 10 inclusive, and the rows give triangles found by using odd integral values from 1 to 17 inclusive for n. The 76 independent or prime combinations are indicated by three numbers showing the values for the three sides of the right triangle, while the 14 other combinations have fourth number in parentheses, which, when divided into each value, will give the basic independent combination to which the dependent combination is related. Expansion of the table may be accomplished by a further substitution of values for k and n with either one or both numbers greater than those used in the table.

Reserve this date . . . .

June 22-26, 1953

ANNUAL MEETING

UNIVERSITY OF FLORIDA

GAINESVILLE, FLORIDA

Report of Treasurer, 1951-1952

Ernest C. Davies
Certified Public Accountant

August 1, 1952

Mr. C. L. Skelley
Technical Book Department
Macmillan Company
60 Fifth Avenue
New York 11, New York

Dear Mr. Skelley:

In accordance with your instructions we have examined the accounts and records of the American Society for Engineering Education for the year ending June 30, 1952 and submit herewith the following statements prepared therefrom:

Exhibit I—Comparative Balance Sheets
Exhibit II—Comparative Statements of Changes in Funds
Exhibit III—Comparative Statements of Income and Expense
Exhibit IV—Comparative Statements of Receipts and Disbursements

In connection with the statements as of June 30, 1952, we examined and tested the accounting records, traced the receipts as recorded to deposit, checked the disbursements, counted the securities on hand, and secured direct confirmation for all funds or securities in the hands of outside parties. Our examination was made in accordance with generally accepted auditing standards and included all procedures which we considered necessary in the circumstances.

In accordance with a resolution of the Board of Directors, the excess of ECRC receipts and budgeted expenditure over ECRC disbursements has been transferred to ECRC reserve.

Also Furniture and Fixtures purchased have been charged against revenue in order to comply with the Board of Directors resolution to carry Furniture and Fixtures at the nominal value of $1.00.

In our opinion these statements fairly present the position of the Society at June 30, 1952 and the results of its operations for the period then ended.

Yours truly,

ERNEST C. DAVIES
Certified Public Accountant

AMERICAN SOCIETY FOR ENGINEERING EDUCATION
COMPARATIVE BALANCE SHEETS

EXHIBIT I

	June 30, 1951	June 30, 1952
Assets		
Current Fund:		
Cash in State Bank and Trust Co.	$21,319.53	$29,627.76
Petty Cash	300.00	300.00
U. S. Government Bonds—Series G	30,700.00	30,700.00
	$52,391.53	$60,627.76

Life Membership Fund:		
Cash	183.11	209.95
U. S. Government Bonds—Series G	1,000.00	1,000.00
	$ 1,183.11	$ 1,209.95
B. J. Lamme Fund:		
Cash—Checking	230.46	163.08
Principal Cash in Hands of Trustee	9.00	9.00
Securities and Mortgages	5,132.73	5,132.73
	$ 5,372.19	$ 5,304.81
Accounts Receivable:		
Advertising	1,560.90	2,747.44
Dues	1,275.00	1,800.00
Westinghouse Educational Foundation	83.91	323.69
Income Cash in Hands of Lamme Trustee	121.46	133.86
	$ 3,041.27	$ 5,004.99
Prepaid Travel Expense	—	425.00
Inventory	1.00	1.00
Furniture and Fixtures	1.00	1.00
Total Assets	$61,990.10	$72,574.51
Liabilities and Capital		
Current Liabilities:		
Accounts Payable—Publications	16.65	—
Other Accruals	1,453.54	407.88
	$ 1,470.19	$ 407.88
Prepaid Membership Dues	$ 1,706.78	$ 508.25
Funds (Per Exhibit II):		
Life Membership Fund	$ 1,183.11	$ 1,209.95
B. J. Lamme Fund	5,372.19	5,304.81
Teaching Aids Fund	4,362.50	6,975.12
	$10,917.80	$13,489.88
General Fund:		
Reserve for ECRC	—	$ 6,004.69
Reserve for Special Projects	$ 6,056.62	6,056.62
Unappropriated Surplus	41,838.71	46,107.19
	$47,895.33	$58,168.50
Total Liabilities and Capital	$61,990.10	$72,574.51

COMPARATIVE STATEMENT OF CHANGES IN FUNDS

EXHIBIT II

	12 Months Ended June 30, 1951	12 Months Ended June 30, 1952
Life Membership Fund		
Balance at Beginning of Period	$ 1,155.87	$ 1,183.11
Add: Contribution to Fund	25.00	25.00
Interest on Fund	2.24	1.84
Balance at End of Period	$ 1,183.11	$ 1,209.95
B. J. Lamme Fund		
Balance at Beginning of Period	$ 5,418.66	$ 5,372.19
Add: Additions to Fund	126.04	228.62
	$ 5,544.70	$ 5,600.81
Less: Award and Expenses	172.51	296.00
	$ 5,372.19	$ 5,304.81
General Education Board		
Balance at Beginning of Period	$ 9,950.00	—
Add: Refund received from SE Section	3,279.02	—
	$13,229.02	—
Less: Refund Made to Gen. Educ. Board	$13,229.02	—
Balance at End of Period	—	
Teaching Aids Fund		
Balance at Beginning of Period	—	$ 4,362.50
Add: Income of Fund	$ 4,570.00	3,605.00
	$ 4,570.00	$ 7,967.50
Less: Expenses of Fund	207.50	992.38
Balance at End of Period	$ 4,362.50	$ 6,975.12
Unappropriated Surplus		
Balance at Beginning of Period	$40,096.08	$41,838.71
Add: (See Notes to Financial Statements)		
Excess Expense over Income	(311.07)	
Transfer from ECRC Reserve	1,315.03	
Transfer from Special Projects	1,486.45	
Excess Income over Expense		$10,273.17
Transfer to ECRC Reserve		(6,004.69)
Net Addition	$ 2,490.41	$ 4,268.48
	$42,586.49	$46,107.19
Less: Write off of Furniture and Fixtures	$ 747.78	
Balance at End of Period	$41,838.71	$46,107.19

COMPARATIVE STATEMENT OF INCOME AND EXPENSE

EXHIBIT III

	12 Months Ended June 30, 1951	12 Months Ended June 30, 1952	Budget 1952-53
Income:			
Current Dues—Individual	$39,113.20	$39,719.28	$39,300
Institutional	6,661.00	8,105.00	9,600
Sale of Publications	2,257.24	2,069.32	2,000
Advertising	9,401.38	10,896.21	13,500
Interest on Government Bonds	792.50	792.50	780
ECRC	1,228.06	3,560.86	—
Income—B. J. Lamme Fund	.02	12.40	—
Refund from EJC	—	407.71	—
Miscellaneous	863.62	—	—
Total Income	$60,317.02	$65,563.28	$65,180
Expense:			
Annual Meeting Expense	$ 2,016.53	$ 2,214.34	$ 2,500
Cost of Publications	24,139.43	22,884.88	24,000
Committees and Conferences	1,153.57	658.22	1,300
Postage, Telephone, and Telegraph	1,416.98	1,565.83	1,600
Supplies and Sundry Printing	2,895.55	3,171.05	2,700
Office Expense	80.27	—	—
Expenses ECAC	1,630.66	1,126.99	2,200
Expenses ECRC	8,379.54	1,906.17	4,350
Officers' Travel Expense	1,694.64	2,365.99	2,000
Secretary's Travel Expense	1,007.73	1,878.71	1,950
President's Expense	460.87	—	500
Salaries	11,018.44	12,658.51	18,600
Bonding, Auditor's Fees, etc.	486.28	321.59	325
Retirement Emeritus	1,360.00	1,360.00	1,360
Dues—Am. Council on Education	100.00	100.00	200
Contribution ECPD	500.00	500.00	500
Miscellaneous	75.31	—	1,000
Special Projects*			
Purchase of Typewriters	291.45		
Purchase of Dictaphones		764.35	
N. Y. Times Reprint	615.71		
Committee on Improvement of Teaching	397.42	815.64	
Contribution EJC	407.71		
Additional Contribution ECPD	500.00		
Purchase of Mimeograph Machine		1,062.84	
Credit on IBM Typewriter		(65.00)	
	$60,628.09	$55,290.11	$65,085
Excess of Income over Expense		$10,273.17	
Excess of Expense over Income	311.07		
Transfer to (or from) ECRC Reserve	$ 2,801.48	$ 6,004.69**	
Balance to Surplus (to Exhibit II)	$ 2,490.41	$ 4,268.48	

* Per resolution of Executive Board, Furniture and Fixtures are to be carried at a nominal value of $1, and any purchases are to be charged as expense.

** This transfer includes income from ECRC publications and the unused budget of the ECRC. It was authorized by the Executive Board, June 25, 1952, in order to give the ECRC an adequate reserve fund to smooth out its fluctuations in expense from year to year.

† The audit of Receipts and Disbursements (Exhibit IV) is available from the Secretary's office.

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
*Allegheny	West Virginia University		C. H. Cather, West Virginia University
Illinois-Indiana	Rose Polytechnic Institute	May, 16, 1953	H. A. Moench, Rose Polytechnic Institute
Kansas-Nebraska	University of Kansas	Oct. 24–25, 1952	M. A. Durland, Kansas State College
Michigan	Detroit Institute of Technology	May 9, 1953	C. C. Winn, Detroit Institute of Technology
Middle Atlantic	Manhattan College	December 6, 1952	W. B. Plank, Lafayette College
Missouri	Washington University	April 11, 1953	G. F. Branigan, University of Arkansas
National Capital Area	Catholic University of America	Oct. 7, 1952	L. K. Downing, Howard University
	Howard University	May 9, 1953	
	University of Maryland	Feb. 3, 1953	
New England	Worcester Polytechnic Institute	Oct. 18, 1952	E. T. Donovan, University of New Hampshire
North Midwest	Iowa State College	Oct. 3–4, 1952	S. J. Chamberlin, Iowa State College
*Ohio	University of Cincinnati	April, 1953	H. K. Justice, University of Cincinnati
*Pacific Northwest	Washington State College	Spring, 1953	J. P. Spielman, Washington State College
Pacific Southwest	California State Polytechnic College	Dec. 29–30, 1952	C. E. Cherry, College of Marin
*Rocky Mountain	University of Wyoming		C. A. Hutchinson, University of Colorado
*Southeastern	Louisiana State University	March, 1953	D. V. Terrell, University of Kentucky
Southwestern	University of New Mexico	April 3 & 4, 1953	M. L. Ray, University of Houston
Upper New York	Alfred University	October 10–11, 1952	R. M. Campbell, Alfred University

Members of the Society are welcome at all Section Meetings

* No Date Set.

A Statement to the A.S.E.E.

on

Youth and Engineering

By GENERAL DWIGHT D. EISENHOWER

The United States is facing critical times, and in the coming years we must make the best use of the vigor, enthusiasm, intelligence and technological skill of young people of this country.

It is true that Americans of an older generation may fix the line and set the goals for conduct of our affairs, but it is just as true that we must depend upon youth to provide the sinews that will carry us toward those goals.

I have spent much of my lifetime dealing with young Americans, and I feel that I know them well. I know particularly well the great initiative and good sense and courage they showed during the second World War. I know that they did not fail their responsibilities. I know the hopes and dreams they held—and still hold—for the future. I do not believe they have been dismayed despite the fact that, after their victory, others blundered or waivered and failed to make secure the peace for which they fought.

The young men and women of America know what they want for the future. They want peace with honor and the opportunity for initiative and self-reliance in the conduct of their own affairs. They want fair-minded and honest government of which they can be proud.

In this regard, our educational system has a greater and more pressing responsibility than ever before. It can encourage diligent awareness. It can arm us with the knowledge we need to protect our freedom and our economic well-being. Schools must fit our young people for the crises of our times or the freedom and opportunities of the schools will disappear in the ruin of all our free institutions. To this end academic freedom must be encouraged, and that means nothing more than specific application of the freedoms inherent in our way of life.

We Americans intend that our young people shall have full advantage of the benefits our country can offer; that they shall profit by our progress in education and health care. I am deeply concerned with the welfare of a free people and with the education and care of our children who one day must assume the responsibilities of preserving that freedom. We must work for the kind of country that will encourage and develop the capacity of parents to provide the care, the education, the religious background and the affection essential to full development of our children and our young people.

But that is not all. Far too many young people suffer deprivations as a result of inflation, high taxes, and maladministration of our affairs. We must reexamine our economic and social policies. In education we must remove hindrances to the exercise of parental responsibilities, and we must strengthen the effectiveness of community action where it is necessary to supplement home influence in the rearing of our youth.

The federal government has both negative and positive responsibility. So far as is possible it must leave the material resources of the country in the hands of the people or in the hands of state and local governments. But it must promote and encourage tested and successful methods of research and

education and health care—both public and voluntary—for the benefit of young Americans. Much of our public effort in this direction has been scattered or piece-meal or too far removed from an understanding of the family, the neighborhood, and the individual citizen. We must strengthen and coordinate these efforts. We must encourage the alleviation of the critical shortage of schools. We must provide better trained and better paid teachers. We must endeavor constantly to raise the standard of health among young people.

I want to do everything in my power to safeguard and improve the opportunity for young Americans. They must have the blessings of self-reliance and freedom. They must have, so far as it is within our power, the assurance of a secure and peaceful world.

The value of engineering and engineering education in securing this peaceful world cannot be overemphasized. The engineer has made many contributions in developing our national economy and our military preparedness program. In our highly complex technological society, the engineer is the creator of our modern tools of production. His efforts are largely responsible for America's great productive capacity and industrial superiority.

During the past World War, I saw engineers and scientists create instruments of warfare which gave our troops overwhelming military and strategic advantages. Their tremendous accomplishments in carrying on the research, design and production of such equipment as radar, the proximity fuse, the atomic bomb, and submarine detection, as well as developing superiority in airplanes, tanks, guns, and ships hastened the conclusion of the war and saved untold thousands of American lives.

Creative ability is one of America's greatest assets—one which we cannot afford to waste. Engineers, already in short supply, must make their contribution to the nation's welfare at their highest capacities where their special training can continue to accomplish miracles of production—our principal weapon in defending our society of free men.

Reserve this date . . . .

June 22-26, 1953

ANNUAL MEETING

UNIVERSITY OF FLORIDA

GAINESVILLE, FLORIDA

Engineers*

By THE HONORABLE HERBERT HOOVER
Ex-President of the United States

I was once a non-resident engineering professor at Columbia University and gave a course of lectures that had all the wit of calculus, the humor of a trilobite and the joyousness of thermo-dynamics. Somebody remembered it about ten years later and paid me with an honorary degree. That entitles me to be on alumni lists for solicitation of funds.

Not all of you are engineers and thus some have not heard me declaim on that profession. This, then, is an opportunity not to be neglected even if I repeat a little.

Men never lose the love for the profession to which they have given years of their lives. The recollection of its joys is the more vivid if one has back-slid onto the slippery path of public life.

Within a little more than my lifetime, the training of engineers has risen from apprenticeship to a trade of secondary technical schools, to the dignity of a University-trained profession. It was the American Universities who pioneered the world in that breadth of training and endowed the profession with great dignity.

As indicative of the distance the engineers have risen in public repute, I might recall that some years ago while crossing the Atlantic I took my meals at the same table with a cultivated English lady. As we came into New York Harbor, at breakfast she said: "I hope you will forgive my dreadful curiosity, but I should like awfully to know what is your profession." I said that I was an engineer. Her involuntary exclamation was: "Why I thought you were a gentleman."

Even yet the scientists look down on the engineers as being something earthy or at least very subsidiary.

As a profession, engineering has both joys and sorrows.

The engineer has the fascination of watching a figment of his imagination emerge with the aid of science to a plan on paper. Then it moves to realization in cement, metal or energy. Then it brings new jobs and homes to men. Then it adds to the security and comfort of these homes. That is the engineer's high privilege among professions.

The profession, however, does have woes. His work is out in the open where all men can see it. If he makes a mistake, he cannot, like the doctor, bury it in a grave. He cannot, like the architect, obscure it by trees and ivy. He cannot, like the lawyers, blame it on the judge or jury. He cannot, like the politician, claim his constituents demanded it. Nor can he, like the public official, change the name of it and hope the voters will forget. Unlike the clergyman, he cannot blame it on the devil.

Worse still, if his works do not work he is damned. That is the phantasmagoria which haunts his nights and dogs his days. He goes to bed wondering where the bugs are which will inevitably appear to jolt its performance. He awakens at night in a cold sweat and puts something on paper that looks silly in the morning.

And the world mostly forgets the name of the engineer who did it. The credit goes to some fellow who used other people's money to pay for it. But the engineer, himself, looks back at the unending stream of goodness that flows from his

* Given at Columbia University, November 7, 1951.

successes with a satisfaction that few other professions can know.

Most people are not aware of it, but the engineer is also a political, economic as well as social force.

I asserted one time that he is the fellow who really dissolves monopolies, redistributes the wealth, and dismantles political platforms. Over our history, one generation after another, men have been elected to office by being sequently "agin" the monopoly of canals, or railroads or anthracite coal or kerosene oil or slums or private development of water power. There were no doubt great evils. But I ask you who really remedied these evils? It was the engineer. He upset the canal monopoly with the railways; he upset the railways with the automobile, the airplane and the pipeline. He upset the anthracite monopoly with coke; he upset the monopoly in kerosene oil with the electric light. He assured that most of the streams would remain as scenery by making cheaper power with steam. Who makes possible the escape from the slums? It is the engineer with his parkways, his bridges, his satellite towns. Who provided leisure for the housewife to play canasta and attend political meetings? It was the engineer with his household gadgets. Sometime the engineer will be needed to put truth into propaganda. But I am getting off the track of amiability.

I hardly need add that it was the engineer who distributes wealth by creation of mass production and his many other devices to reduce costs of production, and thereby brings the prices of a thousand gadgets to the level of everybody's pocketbook. Thus all men become equal before gadgets.

The training of engineers instills character in those who would join its ranks. High ethical standards are the essential of all professions, engineering included. Technology without intellectual honesty does not work. Construction without consciousness soon crumbles. Those are the reasons you have seen no engineers before the Kefauver Committee. Nor in the headlines which these days pour forth Grand Juries and District Attorneys' offices. In the main, engineers appear in public only to sit on juries.

And now after all this exposition surely you will agree that the engineer is an antidote to evil and the bearer of blessings. I hope you will also agree that he is worthy of your attention.

But here we meet a great national problem. We do not have enough engineering teachers and we do not have enough students to carry on the nation's work. And we do not have enough research facilities to assure the needed flow of new inventions and improvements.

One reason for this shortage is that a young mechanic with three years of training, during which he is paid, can earn more take-home pay after taxes than a young engineer with six years of training and three years more of experience. Too often the financing of such training is too expensive for his Dad. Could not more "somebodies" give more scholarships to needy boys who are willing to put in nine years with little reward?

The job of the engineer is to take the discoveries of pure science and convert them into use for the good of mankind. To this end he needs laboratories.

At one time we got our inventions from the genius in the garret. Poverty, however, does not clarify thought. Nor does it provide a laboratory. Bread and butter diet has been discarded as the mother of invention. Today these gifts come from long years of organized search and experiment. Therefrom, like the cell-by-cell growth of plants, fact builds upon fact until there comes forth the blossom of discovery, the illuminating hypotheses or the great generalization. And finally it finds fruition of a multitude of inventions and improvements in living. And it increases the power of a people to pay government debts.

This reminds me that there is one road to rapid recovery of the nation from our present burden of rearmament. That is

to increase our productive power by new technologies and new inventions.

And there are spiritual consequences of research. From them comes the unfolding of beauty, the ever-widening boundaries of thought. Here is the invocation of veracity in a world sodden with intellectual dishonesty. From its discoveries comes the lifting of men's minds beyond the depressing incidents of the day. Here is confirmation of a Supreme Guidance in the Universe far above man himself.

Today the nation needs more and more research and more and more engineers.

College Notes

C. Fred Gurnham is the new head of the Department of Chemical Engineering at **Michigan State College.** His appointment was effective July 1. The 41-year-old chemical engineer has more than 20 years of experience in industrial and educational capacities. He came to M.S.C. from Tufts College, where he had headed the chemical engineering curriculum for four years.

Cornell University students will get some of their basic physics from the television screen beginning this fall. Plans to televise experiments in the freshman and sophomore physics courses were announced by Lloyd P. Smith, chairman of the Department of Physics. The main lecture room in Rockefeller Hall has been outfitted for the project, in which the Radio Corporation of America is ecoperating. Experiments will be televised from the instructor's desk to viewing screens visible from all corners of the room.

Men and women engaged in the building industry, or preparing to enter the field in an administrative or supervisory capacity can now earn a college degree at **Columbia University** while mastering the principles of building construction. This double accomplishment is made possible by the establishment at the School of General Studies, the University's liberal arts undergraduate school for adults, of a major program in Construction Management. Upon completion of the 124-point curriculum, students receive the Bachelor of Science Degree. The Construction Management program calls upon the entire resources of the University. In addition to a minimum requirement of 64 points in cultural and academic courses that give the breadth of background desirable for further professional training, the course of study includes 60 points in professional and specialized courses given in the fields of architecture, engineering, business, and law.

The future bosses of business and industry have a "house to live in" this fall. A modern million dollar building has just been opened to students of the nation's first Graduate School of Industrial Administration at **Carnegie Institute of Technology.** Official dedication took place October 2 and 3. The School was founded January 17, 1949 with a six million dollar gift from the W. L. and May T. Mellon Foundation. One million dollars was designated for the new building and five million was established as the School's endowment.

Minimum Mathematical Requirements for Engineering College Admission and Factors Which Affect This Problem*

A Panel Discussion

By G. C. ERNST

Professor of Civil Engineering, University of Nebraska

Minimum Requirements

The Society's published reports related to engineering college admission indicate that the minimum mathematical requirements have been scrutinized frequently over almost a century, although they have not changed materially during the past 40 to 50 years. During the later years, however, the factors affecting the problem have become increasingly complex.

The "Study of Engineering Education" reported by Dr. C. R. Mann in 1918 provided the following comparison of entrance requirements in mathematics, as typical of that period:

Mass. Inst. of Tech.		*Univ. of Illinois*	
1870	1914	1870	1914
Arithmetic	Algebra A—160 hrs.	Arithmetic	Algebra A—1 unit
Algebra to Quadratics	Algebra B—160 hrs.	Algebra to Quadratics	Algebra B—½ unit
	Plane Geom.—160 hrs.		Plane Geom.—1 unit
	Solid Geom.—160 hrs.		Solid and Spher. Geom.—½ unit

The ever-increasing quantity of engineering knowledge in the various fields has created a desire by some to add plane trigonometry to the above list of entrance requirements, thereby permitting calculus to be taught preceding college physics and also allowing additional hours for engineering courses. Certainly, there has been no desire on the part of engineering colleges to reduce the mathematical requirements for admission, insofar as the published record of the Society's activities are concerned. However any detailed minimum requirements should be evaluated on the basis of engineering college need with due regard to the problems encountered by the secondary schools. As long ago as 1916 (SPEE *Proc.*, Vol. XXIV, p. 103) Dr. C. R. Mann in a Report of a Committee on Entrance Requirements stated ". . . An opportunity exists for the engineering school to bring about an improvement in the matter of entrance requirements by not demanding a unit of this or a unit of that, but by demanding certain abilities and by defining those abilities. . . . If you attack the problem from that point of view, you have a real contribution to make." This is as true today as it was 36 years ago, and is essentially the

* Presented at the Annual Meeting of A.S.E.E. at Dartmouth College, June, 1952.

approach taken by Ferguson, Henderson, Hoelsher, Meserve, Schmidt, and Dickman in their "Mathematical Needs of Prospective Students at the College of Engineering of the University of Illinois," published by the University of Illinois. This publication lists the minimum mathematical needs in very specific terms, with a total of 97 "indispensable topics, with an additional 13 topics recommended for study if time permits." It is interesting to note that the topics listed in 1911 for Algebra 1a, 2b, Plane and Solid Geometry, and Plane Trigonometry in the report on "Definition of Subjects Presented by the Committee on Entrance Requirements," SPEE *Proc.*, Vol. XIX, p. 336, correspond very closely to the 97 "indispensable topics" of the Illinois report of 1951 mentioned above. It seems certain that the mathematics teacher would have little difficulty in interpreting the two lists to be essentially the same.

It may be well to review the factors that have been found to affect the problem of mathematics entrance requirements. For convenience, they are divided into those of the secondary schools and those of the engineering school.

Secondary School Problems

A rather thorough discussion of the problems confronting the larger high schools is provided in "A Report on Mathematics Preparation for Engineering College" by Miller and Roth, ASEE *Proc.*, Vol. LIV, p. 628, 1947. In addition to the problems identified by Miller and Roth, many small high schools in the more sparsely populated areas are confronted with financial difficulties in providing mathematics instruction through trigonometry for the few students that might elect to take it.

Summing up the various problems evolving from the secondary schools, we have briefly:

1. A trend toward less mathematics combined with less emphasis on specific techniques, brought about by a growing belief that the prime function of a high school is to educate all youth and not merely to prepare a relatively small percentage for college.

2. Inability to obtain and hold good mathematics teachers at secondary school level.

3. Lack of practicability of separation of college preparatory students from others, let alone the separation of various college fields of study.

4. Inability to adequately finance mathematics instruction including trigonometry, on the part of the smaller schools.

Engineering College Problems

Although Engineering College problems have stemmed primarily from the growing volume of advanced technical developments that should be included in the 4-year curriculum, there has been a substantial number of the engineering teaching profession who have failed to understand completely either their own problems or those of the secondary schools. This lack of appreciation of the entire question may well be the major problem.

Stating them briefly, the problems are:

1. The proportion of the 4-year engineering curricula at present allocated to a specialized department of study (approximately 30% in the case of civil engineering, for example) is insufficient to cover the necessary quantity of engineering knowledge.

2. The need, on the part of engineering college faculties, to appreciate more fully the growing problems of the secondary school teachers in handling ever-increasing numbers of students, the majority of whom do not intend to enter college.

3. The need, on the part of the engineering college, to make secondary school students, advisers, and teachers continually aware of preparation needs for an engineering curricula.

4. There is a puzzlingly large number of engineering teachers who depreciate the usefulness of mathematics higher than trigonometry, with the erroneous viewpoint that calculus is a higher mathematics for those in research and investigation. It

is not very encouraging to note the recent publication of textbooks at the junior level, mechanics of material for example, in which the major advantage is preclaimed to be the use of no mathematics beyond plane trigonometry. Our editorial reviewers must have developed a rather short-sighted philosophy, and it seems that many engineering educators have need to readjust their sights.

Closure

In closing, it appears to the writer that it is extremely important to keep in mind that we are dealing with a situation calling for far more than a mere statement of minimum requirements and a strict adherence thereto. Every possible avenue should be made available to competent and interested students for entering on an engineering career whether or not the required units in specific mathematics courses have been acquired in the secondary schools. This does not mean that science or engineering courses could be taken before adequate preparation in mathematics but rather that the means to obtain the preparation must be made readily available and the competent student urged to complete it as soon as possible.

Furthermore a sounder understanding of the problems of the secondary schools seems in order, as well as a rather careful self-scrutiny as to our own actions in demonstrating the usefulness of all mathematics including the calculus.

By B. R. TEARE, JR.

Dean of Graduate Studies, Carnegie Institute of Technology

It is clear that the mathematics entrance requirement—making the proper joint between secondary school and college mathematics—poses an important question in engineering education. Mathematics, in addition to being a science of beauty and elegance in its own right, as well as a highly respected professional field, plays a most significant and almost unique role as a fundamental tool for the engineer. By means of it he thinks, and works, and learns, and moreover does these things with an otherwise unattainable precision and economy of effort. Almost all of the courses in the scientific technological part of our curriculum are learned more easily and more thoroughly if the student has an adequate command of mathematics before undertaking them. Consider, for example, the teaching of physics without making use of calculus. It can be done, but it proves to be most wasteful of effort compared with the teaching of physics after even a little understanding of derivatives and integrals. And the same is true of engineering courses. Thus it is desirable to have the student acquire an appropriately substantial background in mathematics as early as possible; the earlier the better from the standpoint of curriculum building.

The significance of mathematics in the admission of engineering students is shown by the great weight attached to the applicant's high school record in that field. He may stand high in a dozen different courses; but if he barely passes in mathematics, he is not a good risk for engineering.

Dean Everitt has precisely stated the problem we face, and I admire the direct and energetic approach that he and his associates have made to its solution, one that goes beyond the conventional requirements of four units of secondary school mathematics to a study and listing of topics that are useful to engineering students. Equally important in his approach is the cooperation that is being built up with secondary schools.

Moreover I am sure that something more than the specification of four units is needed if engineering freshmen are to begin with analytic geometry and do well in mathematics. At our institution we have had some experience that bears on this point. Some ninety per cent of our freshmen are admitted with four units, includ-

ing two of high school algebra and one-half of trigonometry, and for some years we have regularly and to good advantage excused the best of these students—about one-eight—from the normal first semester of mathematics, which is a review and extension of college algebra and trigonometry. Then, in an effort to move gradually toward a curriculum beginning with analytic geometry, we increased the number admitted directly to that course but found that the chief result was an increase in the number of students who performed poorly in mathematics. So we returned to our original procedure and tentatively decided that as far as our students and our particular course in analytic geometry are concerned, a conventional entrance requirement of four units does not by itself guarantee an adequate background for a curriculum beginning with analytic geometry. It may be that we shall find a satisfactory solution if we begin with a differently planned course in analytic geometry, one that allows time for a brief review of topics in algebra and trigonometry as and when they are needed.

Or it may be that our problem will be solved by thinking in terms of needed subject matter as Illinois does, and by joining with other engineering colleges in enlisting the cooperation of secondary schools. It is a fact that the Pittsburgh and Allegheny County Schools have shown a great willingness to be helpful.

It would be of interest to learn the experience of other institutions which for some years have successfully started with analytic geometry.

Emphasis on Genuine Understanding

Our experience also points to the need for another kind of emphasis in pre-college mathematics, beyond that on specific topics of subject matter. I mean an emphasis on genuine understanding, an understanding so thorough that the mathematics learned can be used in real situations, in situations new to the student, and in further learning. This level of understanding, even modestly interpreted, does not on the whole seem to be typical of entering freshmen. It is unfortunate that many high school students are more interested in passing an examination than in building a solid foundation for a professional career. Existing conditions were vividly described by the late, beloved Professor Hedrick in a talk on the same subject as ours this morning and given at the same kind of general session of an ASEE Meeting eleven years ago. He went on to urge that soft habits of thinking be discarded and that standards of performance be raised. I am sure that Doctor Hedricks's advice is still appropriate, and in view of the significance of mathematics in both education and professional work, its teaching for depth of understanding is essential and indeed is of even greater importance than coverage of subject matter. To be really useful to the professional engineer his secondary school mathematics must stay with him all his life, and on it is built not only his college education, but also the considerable learning that he achieves for himself after formal studies are ended.

The foregoing has stressed the need for sound secondary school education in mathematics, and, by implication at least, the need for equally sound mathematics in the engineering curriculum itself, and as early as possible. However we engineering teachers who urge our colleagues in mathematics at both college and secondary school levels to do a good job and to coordinate their activities for maximum performance must recognize that there is a reciprocal obligation on our part, that of making full use of the mathematics preparation in our own later courses. All too often engineering courses at junior and senior levels do not take full advantage of mathematics. I recall that one teacher, some years ago, prided himself on being able to teach alternating current circuit theory without using even calculus! And in other subjects teachers and texts frequently go to great lengths to avoid integrals by using average values which, to make matters worse, are not always clearly defined. Surely this is indefensible either as good education or in the light of what we are

trying to achieve in mathematics. If on the other hand, we use mathematics to the fullest extent, we not only strengthen our instruction, but also, because of improved efficiency, we may save some of the time we need so badly for other purposes in the curriculum.

Coordination is Needed

Let us consider some of the things that can be done to promote efficiency and optimum learning of mathematics. Coordination between courses is indicated, in fact several kinds of coordination. In the first place inadvertent duplication should be avoided, although it is clear that there is a place for planned and carefully handled repetition of subject matter. Timing should be arranged so that fundamental principles and techniques are learned before they are needed elsewhere. The content should be limited to what will be useful in later learning. More subtle and perhaps even more important is planning the character of instruction in mathematics with an eye to its future use in other courses and in post-college learning. And finally, something should be done to insure that mathematics will be used in other courses in such a way as to strengthen and deepen the understanding of basic content, and increase the capacity of the student to use fundamental principles and knowledge to go beyond existing practice.

These kinds of coordination are worked out at college level at Carnegie Tech by our Basic Course Committee on which all the departments concerned are represented. It has helped bring about close cooperation between mathematics and engineering departments, and has contributed significantly to the revision of our mathematics courses.

The cooperative development, as far as possible, of these same kinds of interrelationships between secondary school and college mathematics may help in solving the problem we are considering this morning. Indeed the activity that Dean Everitt has reported is a notable step forward, and I hope that this meeting and the discussion that it generates may point the way to further achievement.

By DR. ROGER B. SAYLOR

Principal, Barringer High School, Newark, New Jersey

I am quite certain that most of us are in agreement that every candidate for an engineering education should have credit for at least two years of algebra and it would be highly desirable to have taken advanced algebra too. He should have a year of plane geometry as well as a course in trigonometry and one in solid geometry. I am told that perhaps the solid geometry is the least valuable of all of these courses. I believe, however, that the course in solid geometry should enable the students to get a better concept of spatial relations. Even this gain in the spatial relations concept can be greatly improved by several courses in general shop work and in mechanical drawing.

It is most necessary that the secondary school pupils be not only exposed to these courses but that they gain a high degree of mastery. To gain this mastery they need to go far beyond the work in just mathematics. The command and the mastery of English is most important. Too often pupils fail to master problems not because of their inability to do the necessary mathematical work but because, through carelessness or lack of word understanding, they have not interpreted their problems correctly. It is most important that the students first determine the aim and objective of the problem presented and then organize the data carefully and systematically so that the logical solution will follow. I always remember the story of the father who took his son to hear a great man lecture. Upon returning home the father asked his son, "Son, how did you enjoy that great man's lecture?" The son replied, "Was he a great man? I could

understand every word he said." Definite understanding and interpretation is most important.

During the secondary school life of the student he or she has been under the careful counseling of trained guidance teachers. The pupils have been studied and helped in every possible way so as to develop their special talents and to give them many opportunities to be introduced to fields of work new to them. In the city of Newark, New Jersey, we no longer offer special courses such as the College Preparatory, the General, the Secretarial or other commonly named courses. We have adopted "Patterns of Study." Every pupil is given a pattern which we hope will meet his or her special needs in life. As the secondary pupils grow and develop they mature in many different ways. Some mature late and some mature early. In each case we try to meet the needs of these pupils. For those who mature early we attempt to enrich their programs so that they will be challenged educationally. Not infrequently you can find these pupils doing work which is of a calibre far beyond that expected of a high school pupil. We secondary school people believe that every child should be given the full opportunity to spend four years in a secondary school. We believe that those who do remain in high school for the four years enter college with a maturity which will enable them to grow rapidly in college. We realize the responsibility that this places upon the secondary schools. The great shortage of future engineers and the apparent failure of some secondary schools has prompted certain foundations to try to entice promising pupils to leave high school at the end of the sophomore year and enter college at that time.

If the present experiment of recruiting engineering students from the sophomores of high school continues then a great deal of the responsibility of the high schools will be transferred to the colleges. Up to the present time, I do not believe that the colleges have adequately prepared themselves for this responsibility. The transition from high school to college, from the home to the dormitory, from associates largely of their own age to older associates is a serious one. Our records show that many high school graduates with fine records frequently do quite poorly in college for the first term or possibly the first year. This is unfortunate for there should be a high correlation between the work of the freshman in college and the work he did in high school. For the student who finds himself early, there is a high correlation. I could cite definite instances of cases within the last year to prove my point. The matter was so serious that the head of my mathematics department checked very carefully with the head of the mathematics department of the college in question to try to solve the problem. In another case at a different engineering college, I wrote to the boy in question and was able to help him find himself so that now he is doing very good work.

Colleges today are realizing that the mere accumulation of facts and formulas is not as important as the ability to understand and apply the facts and formulas given to them. The interpretation of graphs and the summary of facts is most important. I believe the College Board is revising its tests along these lines.

There is another factor, too, which will be of great influence on the future engineering students. Th cost of living has advanced but the salaries of teachers has not kept pace with this advancement. Good science teachers can earn much higher salaries in industry than they can in teaching. In our own city we find it difficult to attract good science men to take our competitive examinations even though we probably pay the highest salaries in the United States for regular teachers. Industry will find it necessary to subsidize good teachers and good schools. I am pleased to say that there are signs of progress in this direction. More scholarships are being offered to promising young students and a number of companies are offering free summer work to mathematics teachers and to teachers of science so that they will be informed of the latest advancements in mathematics and in science.

Let us recognize the facts that the courses in mathematics presented as entrance credits are far from the answer to the problem of our panel discussion. Home background, influence of teachers, the type of community in which the child lives, and many other factors greatly influence the future of these pupils. Not long ago I heard Dr. Bowles of the College Board discuss the work of the Board. He told us how many of the potentially capable and "good engineering college risks" did not find their way to college. I have not lost faith. I am certain that if all of us work together with a mutual understanding of our problems we will continue to turn out "products" from our secondary schools and from our colleges who will keep pace with and go ahead of the needs of our industrial age.

By PAUL D. COLLIER

Chief of the Bureau of Youth Services, State Department of Education, Hartford, Connecticut

I will begin this discussion by raising a question. What should be the qualifications of students sought by Engineering Colleges? In the first place, they should have high scholastic aptitude as measured by standard tests. In the second place, they should have a broad basic general education. They should also have an advanced maturity of purpose developed through a thorough exploration of their interests and abilities. These students should have effective study habits enabling them to make the best possible use of their time and energy. It is highly important that they have physical stamina and emotional stability. These qualifications are necessary for success in other fields of study as well as engineering. In addition to the above qualifications, students seeking admission to Engineering Colleges should be able to present good records in those areas on the high school level known to be basic in the education of an engineer. There are several of these basic areas but the one under consideration is mathematics. While records must be good in terms of time spent and areas covered, should the College of Engineering require that a specific amount of time be spent and definite subjects be completed before the student may be admitted? Before answering this question, I wish to discuss another point.

If the prospective engineering student possesses the above qualifications, then in my opinion the following principle should be accepted and applied: "It is the responsibility of the receiving school or college to make the adjustment necessary to gear the student into a satisfactory, challenging, on-going program." This principle calls for a program tailored to the student's needs and abilities. This principle should apply wherever a learner is transferred from a lower to a higher school. This seems to be the best answer for the individual student.

Specialization

It is now time to raise another difficult question. When should high school pupils begin their programs of specialization or majoring? Certainly, there is no particular grade where this should happen for all pupils. The emergence or development of dominant interests and purposes are determining factors. What is recommended for some pupils will not be satisfactory for others. Earmarking all or a majority of pupils at the beginning of the ninth grade for vocational or college preparation cannot be justified. This common administrative practice generally weakens a sound broad program of common learnings or general education needed by youth. Such a practice cannot be justified in the light of social and economic conditions. There is no need to speed up specialization except in unusual circumstances where pupils must prepare to earn a living at an early age. Even in these cases the manpower needs of the country would not be served through faulty or inadequate general and vocational education of early

school leavers. In forcing early beginnings of specialization or majoring, the period for exploration is shortened, resulting in less maturity for wise choices in the educational program. Counselors and advisors are forced to "box the compass" when the time for beginning specialization is fixed by administrative decree. Interests and motivation are dulled when early choices of program prove to be unsatisfactory. This results in pupils not working up to capacity which encourages the development of time-wasting habits. If colleges insist on set patterns of preparation, they may be unwittingly prolonging the shortcomings resulting from beginning specialization too early.

One of the greatest barriers to functional education on the high school level is the fear of college entrance requirements. Let me define what I mean by functional education. Functional education must be designed for use here and now. It must prepare the learners to face inescapable responsibilities in life as workers, citizens and home members. It must help them solve their personal problems as well as the real problems facing the society in which they live.

A functional program of education is difficult to achieve unless the curriculum organization permits and encourages the problem approach, the unified subject approach to some extent and some pupil participation in planning. I am convinced that the colleges should encourage the development of functional programs in the secondary schools. I believe those students who have a more functional education in the secondary school will be more self-directive and more mature to do college work.

Some of the most promising improvements in education are coming as a result of increased understanding of the learning process and more effective instructional procedures. We should avoid cramping the development of the "American Process" in education by insisting on instructional approaches and curriculum organization which are too formal, in fact outmoded

With the above background, I will now give attention to the field of mathematics. We scare pupils with subjects in mathematics that follow arithmetic on the high school level. Actually, we ought to emphasize the similarities, the kinship of arithmetic to all other subjects in mathematics offered in the high school. We should carefully identify and analyze the competencies of pupils in mathematics as they move from a lower to a higher school and as they approach the time for selecting a new subject in mathematics for study. Necessary adjustments should be made, involving review and tying in the new subject with work previously covered. Mastery and memory are aided in applying mathematics in solving practical problems.

All fields of endeavor, which apply mathematics should contribute real problems to be used in the high school program. Can engineering be a more fruitful source in the future, and contribute real practical problems? Textbooks and curriculum guides are recognizing applications in a great variety of situations, but much remains to be done before a truly functional program is adopted. Again, it should be emphasized that time would be saved through aids to mastery and memory if a more functional program were adopted. Engineering, undoubtedly, has a tremendous contribution to make in this respect. Problems submitted would affect the teaching of all the mathematics that can be offered at the high school level.

Time Factor

The secondary school program is crowded. New demands for time allotments are constantly being reviewed by principals and faculties. One of the most difficult issues faced today concerns the allotment of time to the growing number of curricular and extra-class activities which are being scheduled in the secondary school Allotments of time should be determined on the basis of relative values within the purposes of the school. Since there is keen competition for time, the effective use of time is paramount. Time-serving rather than attaining competency too often seems to be a major goal. The

Carnegie Unit which requires time serving holds the secondary school schedule in a straight jacket. In mathematics generally required for admission to engineering one period for each of 720 days is at present required. Experiments have shown this to be a waste of time. In two Connecticut schools, it has been easily possible for good mathematics pupils to complete first-year algebra in ninety days. Time undoubtedly could be shortened in algebra II, plane geometry, solid geometry and trigonometry for capable pupils. Probably the four years mathematics could be completed in fifty per cent of the time now used. This possibility has many implications.

With a realistic appraisal of the potentialities of capable students of mathematics in high school, many statements commonly accepted should be challenged. For example, the following statement is not true: "Unless a pupil takes mathematics in the ninth and tenth grades, he cannot qualify for admission to a college of engineering." Capable pupils can do more and in less time in the field of mathematics than is now considered possible. It is also assumed that it will take more than four years to graduate students from an Engineering College, who offer less than the usual four years of high school mathematics for admission. This would seem false to me owing to reasons already stated. Time serving may be traditional at the college level also and without valid justification. The fact that gifted and near-gifted youth are not being adequately challenged in secondary school is well known. It is also probably true that they are not being adequately challenged in college.

To solve the problem of establishing competence to begin to learn engineering, by standardizing the time and subjects required, seems unworthy of intelligent professional people. However, this type of thinking and action dominates the senior high school schedule. It also controls the ninth grade in the junior high school. Experimentation is necessary on the local level to convince many principals and teachers that the Carnegie Unit is blocking some of the better developments in curriculum improvement and administration of the secondary school.

Conclusion

In summary, I would like to make the following statements for your consideration:

1. The qualities of high intelligence, advanced maturity, definiteness of purpose, effective study habits, physical stamina and emotional stability are necessary for success in college.

2. Prospective engineering students must make good records in mathematics on the high school level in proportion to the time spent in this field.

3. If a student possesses marked potentialities for engineering, it is the responsibility of the college which accepts him, to tailor his program to mesh with his previous preparation in mathematics.

4. Earmarking pupils for beginning specialization or majoring on the ninth grade level should not be the result of administrative decree, or control of subject patterns by higher institutions of learning.

5. A balanced program, including both common learnings and specialization, should be developed for each pupil on the high school level.

6. The fear of college entrance requirements set up in terms of Carnegie Units is delaying the development of functional education in the secondary school.

7. Mastery and memory in mathematics increase as the curriculum in this area becomes more functional.

8. The present time allotments required in the field of mathematics on the secondary school level are wasteful and do not sufficiently recognize or challenge the abilities and interests of the pupil.

9. Required mathematics on the high school level serves two major purposes; first to aid pupils in solving practical problems of living and second to help determine their potentialities for developing mathematics as a tool in higher education.

10. Engineering colleges should consider entrance requirements in mathematics in terms of competencies for time spent as an alternate for requiring specific Carnegie Units.

The Role of Sponsored Research in Training Research Personnel*

By RALPH A. MORGEN

Program Director for Engineering, National Science Foundation

If there is one point that appears clear in the report of the Industrial Research Institute survey it is that there is no unanimity of opinion. On the other hand there are some general trends and opinions which seem to be favored by the great majority of those who answered the questionnaire.

This discussion is to cover the topic of "The Role of Sponsored Research in Training Research Personnel." The answers to the questionnaire on the subject of "University Connected Research Institutes" showed a sharp division of opinion as to whether or not such institutes were desirable. Since most of the institutions which have affiliated research institutes conduct their sponsored research through those institutes it is appropriate to assume that there would be a similar divided opinion on the whole subject of sponsored research.

It is therefore pertinent to this discussion to review very briefly what it is that an engineering college connected with a university attempts to do.

1. There is unanimous opinion that each university should have the best possible undergraduate curricula in the various engineering areas in which it is interested. In order to maintain this high level undergraduate teaching program the university must employ competent teachers and provide an environment that will encourage them to maintain this level. This implies that the staff will have time for professional development in addition to the teaching of undergraduate courses. Professional development might include activities, such as (a) academic research, (b) industrial consulting work, or (c) industrial employment during summers and on sabbatical leaves.

2. A second function of the engineering college of a university, in addition to the teaching of undergraduate curricula, is to extend the frontiers of knowledge through research. This function implies that at least a portion of the regular staff must have the desire, time and funds to conduct engineering research.

3. A third and increasingly important function of an engineering college of a university is the development of a graduate program for the training of students beyond the baccalaureate degree. It would appear that in engineering and the other physical sciences the nation needs about twenty persons trained at the masters level and about five persons trained at the doctoral level for every one hundred trained at the baccalaureate level. As the complexity of the technological world increases it is quite probable that the percentage of advance degree persons needed will increase compared to the need for first degree level engineers. Dean Hollister, President of the American Society for Engineering Education, has pointed out consistently during the past year that the bottom of the manpower barrel is being scraped for prospective engineering stu-

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The statements are those of the author and do not necessarily represent the policy of the National Science Foundation.

dents. Therefore, it is going to become increasingly important that engineers are educated to the highest possible level. More graduate work is needed to achieve this objective.

4. A fourth obligation of an engineering college connected with a university is to conduct some developmental research with particular reference to the resources of the area in which the university is located and toward the well-being of those industries which exist in the university's immediate area. This is particularly true of those institutions which have received appropriations for an engineering experiment station.

In addition government-sponsored research in the interest of national defense should be undertaken for the benefit of the nation as a whole. Each institution must decide for itself how much of this kind of work it should do depending on the availability of staff and facilities.

It is obvious, therefore, that an engineering college should conduct two types of research; one which shall be called "fundamental" simply for want of a better word, and the other shall be called "developmental," again for the sake of lack of a better word. In many cases the "developmental" type of research might be called basic research by one group and not be considered basic by another. By the the same tenets some of the "fundamental" research might not be considered really basic research by one group or another.

For the sake of this discussion the "fundamental" research shall be considered dimensionless as far as *time* and *economics* are concerned. In other words, it will be a research problem to advance the field of knowledge in which the research worker happens to be interested and which has no direct objective as to when the work must be completed, nor as to whether or not the end of the work will result in an economically sound process, product or machine. Since fostering this type of research is one of the prime obligations of a university, funds must be obtained for this type of research from one or more of several sources. Certainly a portion of the research of this type should be supported by the university out of its own regular funds as part of its ordinary functions. Gifts, grants, and donations from various private sources can be expected to supplement funds needed to support this type of research. The National Science Foundation is the agency of the Federal Government which is specifically empowered to encourage and finance this kind of "fundamental" research.

However, it is clear that if an engineering college is to discharge its functions properly it must conduct some "developmental" research which, for the purposes of this discussion, will be distinguished from the "fundamental" program by the fact that the dimensions of *time* and *dollars* will be an integral part of the program. Since engineering per se is the application of scientific knowledge to the use of man, it is obvious that that application must be done in a reasonable length of time and at a price which a sufficient number of people can afford to pay in order to make the product, process or whatever it is, worth producing.

It is obviously to the advantage of the engineering students to have both types of research in operation at the same institution so that the students may become familiar with and have the opportunity to become proficient in the two types of research. It is not necessarily assumed that the same student will conduct research in both areas during his graduate program but he will have the opportunity to at least choose between them. Whichever program he chooses to follow for his own work he will have some acquaintanceship with the other program through association. The "developmental" type of research should not be done with the university's regular educational fund but rather through contract with agencies which desire to have the work done for a specific purpose (or through engineering experimentation station funds). Those

agencies might be industrial concerns with a specific problem in mind for which a solution is desired or they might be federal agencies, such as the Department of Defense, with specific end-aim objectives in sight. In each case the factor of *time* and *dollars* would *be* an integral part of the program.

There are some who would say that this latter type of program should not be done on a university campus. Exception is taken to that point of view as long as the developmental program continues side by side and complimentary to the fundamental program and not in lieu of it.

This type program is defined for the purposes of this discussion as "sponsored research." For this type of research there are four very distinct advantages on the credit side of the ledger, both for the members of the staff engaged in the program and for the graduate students who are associated with the program. (Parenthetically it should be said that very often research of this type is not satisfactory for graduate students to conduct for thesis purposes but does supply a source of income which makes it possible for the graduate student to remain in school.) These advantages are:

1. REPORTS are an integral part of any "sponsored" research program. There is no better training ground for the writing of clear, concise, engineering reports than to engage in a reseach and development program which requires the personnel to write the results of the experimental program. The report must be written in such form that it will be useful both to the technical personnel and to top management who might not be technically trained.

2. A sponsored research program usually specifies a specific TIME at which certain definite objectives must be achieved. While this sort of time factor often affects adversely certain types of fundamental research the experience of meeting a deadline is a very good one for a graduate student to achieve early in his career.

3. The industrial sponsor of a research program usually has a DOLLAR and CENTS ultimate objective. In the truly fundamental program the kind of material used, the life of the mechanism, the number of man hours involved in production are considered only minor factors if consideration is given to them at all, whereas in the sponsored program these factors often become the dominant or controlling factors. An appreciation of the dollar value of a research program is a very important consideration in the training of graduate students as well as achieving the objective of the sponsored research program.

4. The discipline of working for a specific goal where the "END–AIM" of a research program is established before the work is started is another most important lesson for a graduate student to learn. This lesson can be applied well in a sponsored research program.

At the same time that these advantages are being discussed certain inherent disadvantages in a sponsored research program must not be overlooked. Some of the disadvantages that have been mentioned are:

1. There is a danger that the staff and the graduate students might slight the more basic and more fundamental research programs in favor of the developmental type of program.

2. There is a similar danger that a university will take on a sponsored research program as an overload for the staff and thereby decrease the efficiency of both the sponsored research program and the regular academic program.

3. There is the ever-present danger that a sponsored research program will tend to bring the factory atmosphere into the university, with a consequent loss to the academic atmosphere. A judicious compromise is hard to maintain. It would appear, therefore, that there are four very important reasons why sponsored research should be part of an engineering college program. On the other hand, there are several dangers and disadvantages to such

a program on a college campus. It is believed that the advantages far outweigh the disadvantages and that a properly enlightened university administration can prevent the disadvantages from becoming dominant.

It is agreed by all that a fundamental research program on the college campus is essential for the long term well-being of this country. It is agreed by all that the engineering colleges must participate in this long range fundamental research program. On the other hand, it is also important that the graduate students become aware of the *time* factor and the *economic* factors involved in industrial research programs. This result can be achieved by the proper ratio of sponsored research to academic research.

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Reprints of the **Report of the Committee on Improvement of Teaching** which appeared in the September, 1952 Journal of Engineering Education. Checks and orders should be sent to the Journal of Engineering Education, Northwestern University, Evanston, Illinois. The price is 10¢ per copy in quantities under 100, 05¢ per copy in quantities over 100.

Report of Committee on Atomic Energy Education

The Committee on Atomic Energy Education of the American Society for Engineering Education was appointed in the spring of 1950 by Dean Thorndike Saville, at that time President of the Society. The original committee was composed of the Chairman and Secretary and five members chosen from a list of candidates submitted by officials of the Atomic Energy Commission at each of its major installations. The Atomic Energy Commission at the same time designated one of its staff members at each major installation to be an AEC representative for the region and to cooperate with the local member of the ASEE Committee and with the subcommittees, which were to be appointed by these members from staffs of engineering colleges in their region. The original Committee was composed of the following:

Dean Robert C. Ernst, University of Louisville
Dean Ovid W. Eshbach, Northwestern University
Professor Henry B. Hansteen, College of the City of New York
Dean Morrough P. O'Brien, University of California
Dean Harold E. Wessman, University of Washington
Henry H. Armsby, U. S. Office of Education, Chairman
Dr. Philip N. Powers, Atomic Energy Commission, Secretary

The only change in the personnel of this Committee has been the replacement of Dr. Powers as Secretary by Dr. Alberto Thompson of the headquarters staff of AEC.

At the first meeting of the Committee in June 1950, it was decided that the program could be most effectively conducted through regional subcommittees to be appointed by each of the five members of the main Committee. The Committee outlined the following five objectives to be sought through the cooperation of the regional subcommittees with AEC and its contractors:

(1) To evaluate the responsibilities of engineering education in aiding the growth and development of the atomic energy industry and to determine what there is in the development of nuclear engineering which can be used to enrich and strengthen engineering education.
(2) To assess the over-all needs for engineers with special training in nuclear energy.
(3) To explore with AEC and its contractors subjects or fields for research which may be carried out by graduate students or engineering faculties.
(4) To define the needs of educational institutions with respect to instructional materials (a) for the modification of existing courses in basic science and engineering, (b) for the modification of standard engineering curricula, and (c) for advanced training of engineers planning to specialize in nuclear energy.
(5) To formulate plans for facilitating the flow of needed information regarding such instructional materials to the engineering schools.

The subcommittees have been appointed and have been active, having held a number of regional Conferences. The main Committee has held two meetings subsequent to its first one, and has maintained

close liaison with AEC officials, and through the subcommittee members with the institutions. At least three developments of general interest to the Society have grown out of the activities of the main Committee:

(1) the bibliography "Nuclear Science in Engineering Education," which was prepared and published by AEC in accordance with suggestions made by the Committee,

(2) the highly successful summer symposium which was held at Oak Ridge last summer by the Oak Ridge National Laboratory and the Oak Ridge Institute of Nuclear Studies and sponsored by ASEE through this Committee, and

(3) the "Sourcebook on Nuclear Engineering," suggested by our Committee, which has been approved by the Atomic Energy Commission and will be written by Dr. Glasstone, the Editor of the famous "Sourcebook on Atomic Energy."

At the Dartmouth meeting of ASEE in June 1952 the Committee sponsored a program which was attended by approximately one hundred and sixty persons, who evidenced great interest in the program. The program consisted of (1) a report from the secretary of the Committee on the April meeting of the steering Committee, (2) a paper by Dean Ernst, discussing and listing the engineering courses bearing applications of nuclear energy which are being conducted in engineering colleges, (3) a paper by D. W. McLenegen of the General Electric Company under the title "The Education of Nuclear Engineers as Seen by an AEC Contractor," and (4) an informal discussion conducted by Dr. Keith Glennan, U. S. Atomic Energy Commissioner, in which he presented informally the more significant parts of the staff paper prepared by the AEC technical staff for the use of the Commission in formulating a policy with respect to supplying nuclear reactors for engineering colleges. Commissioner Glennan asked the audience to consider themselves as temporary members of the Commission and to express to him their opinion as to a desirable policy for the Commission to adopt. The discussion following this presentation was very active and the "temporary Commissioners" made recommendations to Commissioner Glennan which he undertook to transmit to the Commission for its consideration.

Copies of the papers by Dean Ernst and Mr. McLenegen will be sent to all Deans of Engineering Schools and to all members of the ASEE subcommittees.

The Committee recommends to the officers of the Society that the Committee be continued, but with a rotation of members and chairman.

HENRY H. ARMSBY, *Chairman*

Lamme Award

The Committee on Lamme Award is always anxious to get nominations for the Award from the membership of the Society. Any member may place a name in nomination; the selection will be made by the Committee by letter ballot.

The Lamme Award consists of a gold medal and bronze replica bestowed annually upon a distinguished engineering educator for excellence in teaching and contributions to the art of teaching; contributions to research and technical literature; achievements which contribute to the advancement of the profession; and engineering administration. The Lamme trust fund was established in memory of Benjamin Garver Lamme.

Until January 15, 1953, the Chairman will receive formal nominations from members of the Society. It is very desirable that nominations be accompanied by a brief statement made according to the outline suggested below.

A number of years ago the Committee set up the following rules for making the Award:

1. Achievements which can be taken as proof of excellence in teaching or as having contributed to the art of technical training will be given major consideration.

2. Only those achievements will be considered which seem to have the possibility of lasting influence or which have sufficiently stood the test of time.

3. Books, articles, contributions to method and research, which have a beneficial effect upon the teaching of engineering, will be given considerable weight in making the decision.

4. Participation in the work of Engineering and Educational Societies is not necessary for eligibility. Such participation, however, will be given due consideration if it has led to definite and recognized results in bettering technical education.

5. Achievements outside of the field of teaching, such as employment in industry, consulting work, inventions, etc., will be considered as of secondary importance in making the Award.

6. Administrators in engineering schools are eligible. Only that work of Administrators, however, will be considered which has led to definite and recognized improvements in method of teaching or in the art of technical training.

7. Emeritus Professors are eligible.

8. Nominations should emphasize the contributions of the candidate to these major objectives Concise statements of achievements are much more valuable to the Committee than a series of recommendations from former students and present acquaintances. Listings in "Who's Who in Engineering," and such publications, give some information regarding achievements but material of this type will not give the Committee the needed information to make a valid judgment.

In preparing a biography of a nominee the following outline should be helpful:

1. Preparation for teaching work—school year graduated, degree, postgraduate work, honorary degrees.

2. Accomplishments as a teacher.

3. Advancement of the art of technical training—books, articles, contributions to method, research, etc.

4. Administrative work in engineering schools.

5. Membership and participation in Engineering and Educational Societies.

6. Engineering practice—employment in industry, consulting work, inventions, etc.

7. Other achievements.

Nominations should be sent to the Chairman of the Committee, Dean F. E. Terman, College of Engineering, Stanford University, Stanford, California by January 15, 1953.

The George Westinghouse Award

The George Westinghouse Award is an annual award established in 1946 by the Westinghouse Educational Foundation to recognize and encourage outstanding achievement in the teaching of students of engineering. The award consists of $1000, together with an engraved certificate. The recipient is selected by a ten-man committee, each member of the Committee serving for a term of four years. There is also a representative from the Foundation. The Award for 1953 will be presented at the banquet of the annual convention at University of Florida, Gainesville, Fla., June 22–26, 1953.

The recipient of the Award must have made a significant contribution to the teaching of engineering students and shall have distinguished himself in several of the following ways:

1. Record as a teacher. (Evidence of superior teaching and guidance of students as demonstrated by records of former students, indications of unusual subject matter competence, etc.)
2. Improvements of the tools of teaching. (Textbooks and student notes, descriptions of special courses or curricula, diagrams and models, new laboratory and teaching equipment, etc.)
3. Other activities contributing to the improvement of teaching. (Material relating to the development of teachers in the nominee's department or teachers in general, the development of testing and guidance program for students, the promotion of cooperation with other types of educational units or with industry, coordination of fields of subject matter, etc.)
4. Evidence of high intellectual capacity. (Brilliance of mind as manifested by contributions to literature, degrees and honors received, etc.)

The Award has been established to encourage younger men who have shown by their past record evidence of continuing activity as superior teachers. To them the Award may serve not only as a reward but as an incentive toward further achievement.

In order to achieve this intent, it is deemed essential to limit the Award to those who have not reached the age of 45 by the date of the annual presentation.

Nominations may be made by any person, organization, or group and are to be submitted before January 15, 1953, to the Chairman of the Committee on Award, Professor F. B. Seely, Professor of Applied Mechanics Emeritus, 120 Talbot Laboratory, University of Illinois, Urbana, Illinois. Nominations must be made on forms available from either the chairman of the Committee or from the Secretary of the Society. Nominations should be accompanied by significant evidence supporting statements and claims.

Government-Supported Research*

By DR. ALAN T. WATERMAN
Director, National Science Foundation

I welcome this opportunity to meet with the Southeastern Section of the American Society for Engineering Education at its annual meeting. I have been invited to address the meeting this afternoon on the general subject of Government support of research. However, the extent and diversity of Government support of research and development are now such that it would probably be more meaningful if I were to approach the subject from the viewpoint of the National Science Foundation, which has just marked the end of its first year of operation.

The Foundation has a three-fold mission: the development of a national science policy; the support of basic research through grants, contracts, and other forms of assistance; and the furtherance of education in the sciences through the award of fellowships in the natural sciences, and through other means designed to strengthen and encourage education in the sciences. The establishment of the Foundation by the National Science Foundation Act of 1950 occurred at a critical time in terms of the national need. Although Government expenditures for research and development are at an all-time high, all but a relatively small portion of the total is being spent for applied research and development vital to the national defense. In 1941, the estimated total research and development expenditures in the United States were $800,000,000 of which the Government spent $240,000,000, or approximately 30 per cent. In 1952, the total national expenditure for research and development is estimated at $2,930,000,000, of which the Government is spending $1,640,000,000, or 56 per cent of the national total. In 1952, industry is spending an estimated total of $1,190,000,000 on research and development, or 41 per cent of the national total; while the universities are spending only $100,000,000, or about three per cent of the national total.

The work that is going on in the universities, though much smaller by dollar volume than either Government research or industrial research, is nevertheless a highly important part of the over-all effort, for it includes a substantial portion of the basic research being supported in this country, and without basic research both applied research and technology would ultimately come to a halt.

The National Science Foundation is operating on a very small appropriation, only $3,500,000 for fiscal 1952. The outlook for additional funds in 1953 depends upon action by the Senate Appropriations Commitee and subsequent action by the House and Senate. Approximately 40 per cent of this amount is being spent in support of basic research in the universities, and a similar amount for predoctoral and postdoctoral graduate fellowships in the natural sciences.

We regard the graduate fellowship program as of special importance at the present time because of the critical shortages of trained personnel in many of the natural sciences, and particularly in engineering. Another highly significant aspect of the scientific manpower problem is the need that has just begun to emerge for special combinations of training, par-

* Abstract of remarks made at Southeastern Section Meeting, Clemson College, April 10, 1952.

ticularly among the fundamental physical sciences and various branches of engineering. For example, the electronics engineer has sprung up as a hybrid between the physicist and the electrical engineer. The atomic energy program has resulted in the need for combined engineers, nuclear physicists, and chemists. Another important need is for chemists and for solid-state physicists for problems in materials and some forms of construction engineering.

With scarcely a year in which to operate —1952 funds became available only in November of last year—the Foundation has not had time to gather all the data needed for a full assessment of the Nation's scientific needs. The gathering of such data is preliminary to the development of a national science policy. The Foundation feels that the Nation's scientists and engineers are the persons best qualified to assist in the assessment of national need. Accordingly, we are calling upon scientists and engineers from all parts of the country to assist us as consultants and advisers in the gradual development of an over-all picture of the national needs in science.

It is a matter of special gratification and interest that the South is contributing more and more of its great natural resources, both human and material, to a variety of research and development activities. The South is particularly to be congratulated upon its awareness of these problems and for the positive steps it is taking to solve them. It is important to the Nation to be able to look to the South for important new contributions in the field of research and education in the sciences.

Reserve this date . . . .

June 22-26, 1953

ANNUAL MEETING

UNIVERSITY OF FLORIDA

GAINESVILLE, FLORIDA

Teaching with Color*

By WILLIAM C. KRATHWOHL

Director of Tests, Institute for Psychological Services, Illinois Institute of Technology

Color can be so useful in effective teaching that it is a wonder it has been used so seldom. Although it has exceptional usefulness in mathematics, many of its applications, with a little ingenuity, can be transferred to other subjects.

Some of the uses of color are for clarity, emphasis, analysis, economy of effort, and interest. Often these uses overlap. An instructor who has not used colors in the classroom cannot realize how many opportunities he has missed, where, by means of colored chalk, he might have stressed a point more emphatically or cleared up a statement more effectively.

Color is not only applicable to drawing pictures in geometry but it can also be used in such subjects as engineering, technical drawing, arithmetic, algebra, English, the physical, biological and social sciences and the humanities.

Clearness

As an illustration of the use of color to promote clearness, consider a problem involving the operations of addition and subtraction in algebra such as:

$$3a - 2b - 5c + 6b - 2a + c = a + 4b - 4c.$$

If pink is used wherever a occurs, green with b and blue with c, and if the two sides of the equation are compared, it does not take much imagination to see how the pink quantities on the left give the pink quantity on the right, the green quantities on the left give the green quantity on the right, and the blue quantities on the left give the blue quantity on the right. If it becomes awkward to write the quantities in colors, good effects can still be obtained by writing the equation in white chalk and then using colored chalk to check off or encircle similar quantities. To see the same thing with the equation written in black and white, as is done on this page, requires, even in such a simple case, a certain amount of searching.

Frequently verbal problems can be simplified by using colors. Take the problem of a rectangle with changing sides. Here, the original rectangle can be drawn in black and white, whereas the changed rectangle can be drawn in colors.

Mathematicians and engineers often have to draw pictures and even though they may not be rated as artists, color can compensate for their artistic deficiencies. For an example, consider the complicated figure which arises in the computation of a volume by means of triple integrals. If rectangular coordinates are used, it is necessary to slice the volume into slabs, the slabs into columns and the columns into rectangular parallelepipeds. If a rectangular parallelepiped is drawn in yellow, a column in red, a slab in blue and the volume itself in green, the student can easily see how to go from one type of volume to another without a lengthy explanation.

As another illustration consider the case where there may be two triangles which have to be pointed out in a complicated figure. Instead of talking about the triangle ABC and the triangle DEF, if the instructor talks about the red and yellow triangles, the student is able to see these at once. Otherwise he hunts around try-

*Presented before the Mathematics Division at the Annual Meeting of the ASEE, Dartmouth College, June, 1952.

ing to find where A is, then where B is and then where C is. Often by the time he has found B and C, he discovers that he has lost A and has to start all over again. Add to these troubles, his difficulties in finding D, E and F, and it is no wonder that confusion becomes worse confounded. To say that using colors instead of letters is an economy of effort is putting it very mildly.

Another instance occurs not only in geometry but also in trigonometry, where it is necessary to associate an angle with a side. Here the angle can be shaded in the same color as that in which the opposite side is drawn.

Solid geometry lends itself particularly well to color in such complicated figures as the division of a triangular prism into three equivalent triangular pyramids. Each pyramid can be drawn in its proper position in the triangular prism with a different color and the student then can see the relation of each pyramid to the other pyramids and to the entire figure without stopping to hunt for letters. Furthermore where a red triangular pyramid and a green triangular pyramid have a line AB in common that line can be drawn in the two colors, red and green, side by side, to distinguish it from those edges which are not common to two pyramids.

Another illustration in solid geometry is to show the intersection of two planes where each plane is drawn in a different color and both colors are drawn side by side for the line of intersection. Such a device is of real help to students who have great difficulty in the visualization of three dimensional space.

Emphasis

Common errors can be pointed out by using colors for the correct procedures without the danger of strengthening wrong ideas by calling attention to them. Consider the operation of multiplication by zero, where the common error is to say two times zero equals two. If a set of equations such as:

$$\begin{aligned} 2 \text{ times } 0 &= 0 \\ 544 \text{ times } 0 &= 0 \\ x \text{ times } 0 &= 0 \end{aligned}$$

are written with all of the zeros in a brilliant red, the picture of the equations with red zeros will remain long after the black and white equations are forgotten.

Another illustration is the correction of commonly misspelled words such as "adieu" which is sometimes spelled "adiew," or "integral" which some engineering students spell and apparently pronounce "intergal." One way to help remedy such misspelling is to write correctly in colors just that part which is commonly misspelled.

A third illustration, when using functional notation, is to emphasize the fact that if a substitution is made for a variable, it must be made in every place where the variable occurs but must not be made anywhere else. Such a function might be

$$f(\mathbf{x}) = 2y + 7\mathbf{x} + (\mathbf{x} + 2a)\sin \mathbf{x}.$$

Let us suppose that in this instance $f(x)$ is to be found for $x = 3$, then its value becomes

$$f(3) = 2y + (7)(3) + (3 + 2a)\sin 3.$$

If the letter x is written in pink on both sides of the equation and if the number 3 is written in pink wherever the pink x occurs, the fact will stand out boldly to the student that he must substitute the number 3 wherever x occurs and that he must not substitute 3 for anything else.

Analysis

Color will help to analyze the operations in some problems as no other method will do. Consider the simplification of a fraction which has common factors in both numerator and denominator. If each cancellation is made with a different color the variegated picture which results will show, clearer than a volume of words can do, every cancellation which is involved and, what is more important, where that cancellation has been performed.

Consider also long polynomials which

sometimes occur in engineering, mathematics, and the sciences, and which simplify to a large extent because they contain several groups that add up to zero. If a different color is used for crossing out each of the different groups which add up to zero, then it is easy to see just what is going on. Otherwise the student gets lost and confused and is apt to adopt the attitude that the operations are being performed by his instructor who never makes a mistake, and hence they must be correct. Such an attitude makes for poor teaching.

Miscellaneous

Correcting examination papers with colored pencils can prove very informative to a student. The instructor can write on the examination paper useful hints and corrections and there never is any argument when the paper is returned as to who made the corrections.

Another use for color is in keeping records of students where a number of examinations are given during a term. Here subtotals or percentages can be written in red along the same line in which the individual records are written with some other color. Thus the general trend of the work habits of a student becomes easily apparent. Such a trend, if downward, can be called to the student's attention before it is too late and such constant vigilance on the part of an instructor gives to the class the very important impression that he is on the job every minute.

Some interesting by-products of using color occasionally turn up. For instance, there once was a student who complained that at times his instructor claimed he was drawing some lines, but the lines never appeared. The mystery of the vanishing lines was solved when an investigation disclosed that their strange disappearances always happened when the instructor was using red chalk on a dark blackboard. It turned out that the student was color blind and had not been aware of it.

A word of caution should be noted here about which colors can be used. Many chalks on the market are so dark that they do not show up well on the usual blackboards. Golden orange, pink, apple green, sky blue, straw yellow, and other pastel shades show up the best.

Another caution that should be observed by instructors using colored chalks for the first time is the question of allergies. Some hardy souls can handle anything but some instructors, who have no trouble at all with white chalk, have been known to be allergic to a few of the dyes which are used to produce some of the colors.

Interest

Leaving everything aside, if all the reasons just advanced for using colors in the class room were invalid there still would remain the best and most powerful argument for their use, and that is their arousal of interest.

In some respects the world of black and white is a world of unreality. Who ever heard of eating a black and white tomato? The classroom should stimulate real life conditions. White has a discouraging bleakness about it that discourages morale. There is physical fatigue in distinguishing white from black which is not present when colors are used.

On the other hand, the teacher who uses color has an added device for focusing attention. Not only are colors more pleasing to the eye, but sometimes they stimulate the curiosity of a certain type of student and keep him guessing as to which color his instructor is going to use next.

Furthermore, under proper conditions, color can have a dynamic effect. For instance, some color specialists maintain that magenta lights at parties have the same effect on guests as at least two cocktails, but at considerably less expense and without any unfortunate after effects.

Colors are sweeping the business world today as they never have before. Just notice the increasing number of pages in color which magazines, such as the *Saturday Evening Post*, are producing each week. One commodity after another has capitulated to their sales-building influence. Colors liven the senses and keep the

individual alert to action. They do not give the mind a chance to brood. People are more carefree and happy, and are more active in a setting of nature in her most beautiful dress of sunlight and bright colors. Color, with its gorgeous reds, brilliant greens, sparkling yellows, vivid blues, and deep purples, can cover the entire visual field with a minimum expenditure of physical effort.

If all this is true and it seems reasonable that it is so, instructors ought to replace their grim and dismal whites and blacks in the classroom with colors, and make their lectures more fascinating and interesting.

Young Faculty Members . . . . .

PAPER COMPETITION

ELIGIBILITY: Members of ASEE not over 36 years of age in June, 1953.

AWARDS: First prize $200—Second prize $100.
Awards will be presented to recipients at the Banquet at the Annual Meeting of ASEE, University of Florida, June 25, 1953.

SUBJECT: Papers should deal with some constructive phase of improvement of engineering education. Participants are encouraged to select their own subject matter and titles within the broad framework of improvement of engineering education. In general, the papers should not be of a technical nature. The following are suggestions of the type of subject matter to consider:

a. How can the student learn to deal with new and unfamiliar situations with originality and well-ordered professional thinking?

b. What are the most important qualifications of undergraduate teachers of engineering?

SUBMISSION OF ENTRIES: All papers are to be submitted to the Chairman of the ASEE Section to which the participant belongs. For a list of Section Chairmen, see the Section Meetings, page 185 in this issue of the Journal. For further information and final date of submission of entries, write to your Section Chairman.

JUDGING: Each Section will appoint its own judging committee and select one winning paper. The winning papers from the Sections will be reviewed by a national judging committee for the final awards.

Here's Your Opportunity to Achieve National Distinction!

The Secondary School as a Source of Candidates for Engineering Training*

By HARRY A. JAGER

Chief, Guidance and Personnel Services Branch, Division of Vocational Education, Office of Education, Federal Security Agency

The subject, "The Secondary School as a Source of Candidates for Engineering Training," is chosen advisedly. The presentation about to be given was selected presumably because the assistance of secondary schools and particularly of guidance services was recognized as crucial to filling the ranks of engineers to the extent necessary in the manpower requirements of these times. This request reflects the far-sighted policy of the Engineer's Council for Professional Development and its Guidance Committee; of the American Society for Engineering Education; and of the Engineering Manpower Commission of the Engineer's Joint Council, in their task of mobilizing the engineering profession to meet current demands.

Some Basic Assumptions in Secondary Schools

Secondary education, fortunately for these purposes, is at the moment in the midst of a great development of guidance services which have among their objectives a choice by young people of the kind of work they should engage in, their training for it, entering upon it, adjusting to its conditions, and progressing in it. These objectives, often known as those of vocational guidance, are really part of a larger program more appropriately named guidance services. They are now manned in thousands of schools by persons called counselors, whose ideal preparation consists of a comprehensive range of training derived from what amounts to a new discipline among the professions. The implications of these guidance services extend from the earliest grades through the colleges and universities and into adult life. They are important not merely for choosing a vocation, and other problems of individuals, but also for many activities of teachers and even for the course of curriculum development, functions which are more and more making them integral with the total educative process.

The expression "thousands of schools" leaves a considerable gap in a program where even more thousands of schools are without trained counselors. There are hopes that these gaps may be filled at an accelerating pace. Since, however, they still exist, any plans aimed at increasing the supply of engineers in which secondary schools are involved must be usable by all schools. It is impossible to reach enough persons to answer the needs of the engineering profession unless all students enrolled in high schools, large and small, rural and urban, with or without organized guidance programs, are included in the group.

One reason for this introduction to this talk is the need for recognizing a fact which is not always apparent: Neither secondary schools nor guidance services either are or can be engaged in a program of recruitment as such. The point of view which must be maintained is that young people in a democracy have a free choice in matters of training and

* Presented before the Engineering Section of the Land-Grant College Association November, 1951 in Houston, Texas.

vocation. These choices should be based on their knowledge of their abilities and interests as well as a familiarity with all opportunities open to them in the economic world in the light of these interests and abilities. Any warping of this objective approach in the interests of a need, no matter how critical, would be a subtle but real undermining of the democratic process. This protection of the intelligent self-interest of the individual is, it is believed, in no wise irreconcilable with an increase in the supply of *suitable* candidates for the engineering profession. On its merits, engineering is a good choice for many young people who are now not considering it as a career. It not only fits their pattern of abilities, but in sheer numbers among all professional opportunities has unquestionable rights for attention.

The reservations just cited, it is thought, present no real barriers to the engineering profession as it seeks more and better candidates for its ranks. They do point out, however, channels of approach which, if somewhat restricted, strike straight and sure to the goals established. Meanwhile the schools seek answers to several questions.

What is the Demand and Supply with Respect to Engineering Candidates?

The first question that we may examine is "What are the needs for manning engineering and what is the supply in secondary schools to fill these needs?" The year 1951 is chosen as the point of orientation, both for high schools and engineering colleges. The choice of a current year enables us to deal at least partly with facts rather than prophecies, and reduces data based on estimates to a minimum.

From a report entitled "Engineering Manpower in the United States," by Armsby,[1] certain facts can be assembled. These facts in turn refer to an earlier paper, "The Future Supply of Engineering Graduates," also by Armsby and dated June 1950. Here are some interpretations of these facts in certain significant relationships:

The estimated need for new engineering graduates for civilian purposes in 1951 is 70 thousand, a number expected to be reduced as the years go by until the permanent need settles to about 30 thousand a year. As a compromise, 35 thousand is accepted as a reasonable goal, partly because engineering degrees in 1951 were approximately of this order. (The actual figure was 38 thousand.) The number of high school graduates in 1951 was some 1 million 240 thousand, of whom approximately 600 thousand were boys, the only realistic source for engineering material at this juncture. To produce 35 thousand graduates over a period of years and in normal times (this is, discounting veteran enrollment) 70 thousand freshmen are required, because approximately only *49 per cent of freshmen survive to graduate*. Seventy thousand freshmen is about 11 per cent of all the boys graduating from high school in the current year and in any of the next 4 or 5 years to come. But for all practical purposes, only the top half of the boys in any graduating class are acceptable for college entrance, which raises this figure to 22 per cent of boys available in any year. In other words, to satisfy the estimated need for engineering freshmen, 1 boy out of every 5 going to college from all graduating classes must choose to study engineering. Over against these figures is the fact that the best authenticated percentage of high-school graduates becoming engineering freshmen over a period of years is 2.9 for the entire group, which, reduced to boys only, becomes 5.3, and to the top half, 11.6 per cent.

A most significant question arises here: Is there any reasonable expectation that the proportion of boys not merely choosing engineering but also qualified to take

[1] Address before the Upper New York Section of the American Society for Engineering Education, October 1951, by Henry H. Armsby, Associate Chief, Engineering Education, U. S. Office of Education.

engineering can be doubled this year or in any year to come?[2]

The answer to the question just proposed is apparently a resounding "No," and for several reasons. One is that college students for all goals must come out of not more than the top half of boys in the average graduating class. A second is that thousands of small schools do not offer some of the courses considered essential as preliminaries to engineering education, so that the total of boys available is appreciably less than the 300 thousand in this top half. A third is that practically all the old professions, except perhaps law, and some new ones, are making similar claims fo undermanning, and are endeavoring to get, maintain, or increase their shares of the national quota. Recruits for one profession cannot be doubled except at the expense of one or more groups. In the fourth place the alleged instability of engineering as a permanent career has attained so much prominence that boys looking 5 or 6 years ahead may well question, not the figures proposed by learned societies and Government agencies which they know nothing about, but whether they actually will have a job in engineering when they want one 5 or 6 years from now.

At this point someone may say, "Let us enroll the girls." This may be a feasible recourse, but any feeling of complacency or magnanimity involved in this decision will meet with immediate deflation. It the hurdles of suitable interests and aptitudes (abilities are omitted because all measurements indicate that girls equal boys in range and amount of abilities) and acceptability on the job are waived, the recruiters will be faced by the current enormous demands for girls in the "women's" professions—nursing, teaching, and office occupations. In addition dozens of fascinating fields have opened up for women in the last 10 years which would compete at least on even terms with engineering. Finally, want-advertisements in the newspapers of our larger cities are offering young women with a minimum of experience and perhaps no more than a year's education beyond the high school, salaries which compare very favorably with entrance salaries for male engineers. And, after all, what most girls want to do is to get married.

This dilemma is not one which faces engineering alone. It is part of the situation which has increased the labor force to our current 65 million, has reduced the unemployed group to a mere million or so, and which can depend upon the 2 million young people reaching 18 years old each year as the only permanent and reliable addition to its numbers. Since the military can and will enforce its demands before those of any other labor requirements, the situation has reached a stage as crucial as has ever faced the Nation. Engineering, like all other professions, must face these facts and arrive at some workable compromise to achieve its goals.

To sum up: If the boys needed are actually available from current high school graduating classes, the supply is strictly limited and offers no hope that ordinary recruiting can draw from a inexhaustible group of candidates. If needs in engineering are stated accurately, other measures are called for.

How Does "Normal Attrition" in Engineering Schools Affect the Problem?

The second question in which secondary schools are interested is, "What happens to our boys after they enter the engineering school?"

From the sources already cited appear devastating facts. There can be little expectancy that, taking all institutions as a group, more than 49 per cent of engineering freshmen will become graduates: that is, roughly 1 out of 2 is lost. This process has frequently been described as "normal attrition," as if boys were particles on an emery wheel which can be justifiably re-

[2] The military service question is deliberately left out of these calculations. If it were included all figures would likely be worse from the point of view of engineering goals.

duced to sparks, dust, and heat, provided the engineering profession attains its proper polish. Since a school regards every pupil who attends it as something precious with inalienable rights of his own, "normal attrition" is a phrase not merely repugnant to school people as a whole, but particularly repulsive to those engaged in the guidance profession.

Attrition figures apply to other colleges than engineering schools and, in fact, engineering schools do better than 4 out of 7 other professional schools in these respects. It is true also that almost the same figures apply to young pepole who are graduated from high school as compared with those in the sixth or seventh grade, but this condition is recognized as an evil against which many campaigns for staying in school are addressed, and which has been overcome in some states so that 90 per cent or more young people of high school age are in high school. In any case, in these times when no manpower can be wasted, the phrase "normal attrition" should be analyzed. If it represents evils which can be remedied, any campaign in secondary schools should be buttressed by evidence, first, that this evil is known and, second, that steps are being taken to remedy the causes, at least in so far as they are remediable.

Diligent search has not revealed any national study of the causes for attrition since the bulletin, "College Student Mortality," published in 1937 by the Office of Education and sponsored by 25 university projects staffs. Although 14 years may have changed details, in the absence of other evidence the data cited may be deemed acceptable, with whatever reservations may be necessary in view of changed conditions.

In this study of 100 students who left schools of engineering before graduation (the total number on which the figures were based is 1544), 19.9 per cent were dismissed for failure in work; 3.2 per cent for lack of interest; 1.1 per cent for disciplinary causes. These three are grouped together since they may be considered to have relevancy to each other, and make a total of 24.2 per cent, or a quarter of the number. Ten and seven-tenths per cent left for financial reasons. Death and illness accounted for 4.1 per cent, miscellaneous causes for 13 per cent, and *unknown causes for 48 per cent.* Of all these causes only a few can be accepted as based on firm evidence, of which the most stable is probably that for death and illness and that of low scholarship grades. The most startling fact is that nearly half the cases involved youth who made so little impression upon the institutions that they dropped out of sight without anybody knowing why, and another eighth were but dubiously classified as "miscellaneous."

Undoubtedly better student personnel programs established in engineering schools within the last 14 years are responsible for reducing mortality rates from 60 per cent noted in 1938 to 51 per cent acknowledged today. Current figures merely cite the total number in the freshman class and the total number of graduates. There has always been a steady influx of transfers into the advanced classes in engineering schools, and it is possible that a study based on individual survivals, as the 1937 study was, would show worse figures than those available now.

Relation to the Manpower Problem

The interests of secondary schools in these facts, grave as they are, are of less consequence than their relation to the manpower problem. Neither an institution training for the professions, nor any employer, can, under current circumstances, ask for two persons to be assigned to it so that it may at its leisure choose one and reject the other. During the more or less prolonged period in which the individual is retained, although ultimately rejected, he is deprived either of some training in which he might succeed better, or of participating in production, and of not only earning his living but even of doing his share in the defense of his country, both on a civilian and a military basis. To the extent that this practice is

sheer waste, it should be eliminated at once. Of all professions, engineering, which has as its goal the scientific adjustment of means to ends, should be the most eager to eliminate waste in its own house.

It is not the purpose here to place any blame in these respects, in which all educational levels from the first grade up are culpable. But from the point of view of young people, parents, and the secondary schools which are asked to aid in recruitment, certain statements might not seem out of line. For instance, engineering schools, ordinarily admit freshmen by their own standards applied to preparatory subjects, rank in school, and personal characteristics, all of which are a matter of record in most schools, and should be in every school.

Tools for evaluation and selection, long a matter of study by authorities, including members of your own guidance committee, are increasingly accurate, both for selection and admission purposes. Should then 1 in 4 (9 thousand on a basis of 35 thousand drop-outs) engineering students leave college because of their inability to be interested in or succeed in their studies? How much of this assigned cause has its roots in poor teaching, obsolescent subject matter, crowded sections, or the lack of application of those very tools of evaluation to the teaching process in college? How much is caused by institutions bypassing, or failing to apply strictly, accepted standards in case of entering freshmen? The dilemma's two horns are: If these drop-outs are inept, how do they get into the institution; and if they are apt, why do they fail?

Or, again, is there any excuse whatever for any able student's leaving for financial reasons as 1 in 10 (3500 persons) do? If public funds are not available to keep these young people in school, why should not those employers to whom the young engineer is the most precious of all commodities hesitate to supply enough money for this purpose, a sum negligible compared to amounts now spent, let us say, for such recognized needs as advertising and research?

Thirdly, what about the 50 or 60 per cent (18,000) who leave for "miscellaneous" or "unknown" causes, who must be so classified only because enough pains have not been taken, first, to learn the causes of maladjustment as they accumulate, and secondly, to remedy the very large number of cases which are undoubtedly remediable?

It is clear that numbers of these questions are not now answerable. It is readily admitted that many institutions are studying them and doing what is possible to change conditions. But extraordinary times demand extraordinary measures. A profession cannot demand the doubling of its quota of young people who choose it at the expense of other professions, and at the same throw to one side half the young people who actually are admitted to training. In the presence of so many emergency measures, many of them involving billions of dollars for which no one questions the value received, the engineering profession can well recommend and adopt measures which will answer at least in part this charge of waste. It should be clearly kept in mind that both on the basis of experience and of prophecy, 35 thousand graduates in engineering involve another 35 thousand real persons, mostly from the top half of ability among the boys in graduating classes of all high schools in this country, who land in the discard. The question of their partial gains from what engineering work they have received and their presence on the campus, as well as the fact that they are undoubtedly absorbed promptly somewhere in the military or civilian labor force, is beside the point. They have not proceeded to their chosen objective. The time, money, and resources devoted to making them engineers is, for that end, wasted. And most of all, the future score in frustration and maladjustment of everybody concerned is only beginning to be realized.

The Case for Engineering As a Choice of Profession

What is the case for engineering as a career which warrants its consideration by any bright and apt high school pupil? On its merits, a strong one. Current estimates place 3 million men in the professional and technical segment of the labor force, of whom 400 thousand are engineers, approximately 13.3 per cent, or better than 1 in 8 of all professional jobs. In schools in which a professional career is the obsession usually for more than half of all those enrolled, a profession which supplies 1 job out of every 8 has a strong claim for consideration. As a matter of fact, in this ratio it would supply careers for 37.5 thousand out of the 300 thousand boys in the top half of the graduating classes—a figure corresponding approximately with some of the estimates as to the stable needs of the country for engineering graduates.

Again, enough high school students who have the necessary abilities to warrant an expectation that they are likely to succeed in engineering can probably be identified and become available. Fortunately the valuable work done by the Guidance Committee of the E.C.P.D. is supplying criteria which can be applied to every high school to aid in judging in these respects.

Thirdly, as young people study the social and economic significance of the professions, engineering has claims which are only partially either understood or advanced in the consideration of a career. Rightly or wrongly, in this atomic age they are achieving emphasis out of proportion to anything that has happened up to this time. It would be of advantage even to engineers in this connection to review the remarkable chapter by Stuart Chase called "Prometheus Enchained" in the A.A.E., publication of 1933 entitled *Vocational Guidance in Engineering Lines.* The influence of this social importance, of this appeal to idealism and its leadership, for young people can scacely be overemphasized. The usual approach of wages received, the prestige involved, and the ultimate command of wealth are powerful stimuli, it is admitted. Yet all young people from 15 to 18 have a strong strain of idealism which leads them to give a ready hearing to proposed life work which enlists them in the betterment, not merely of their own country, but also of the world. To attain this understanding, of course, something more than the processes of selection and vocational guidance are necessary. Into the teaching of the school must go new elements, especially in the social studies curriculum. This approach is difficult, but numerous attacks are already being made as, for instance, by the Joint Committee on Economic Education. The point is that engineering as a profession should early enter the consciousness of the adolescent, and accumulate in force for sound and broadly based reasons rather than as a result of the impact of recruiting posters and emergency decisions.

What Can Be Done?

What can be done in engaging secondary schools in a serious cooperative endeavor to supply engineering skill to the Nation should be settled on a realistic basis. Any plan advanced should be founded on facts of manpower, the purposes of high schools, the ability of engineering colleges to cooperate, the good will of active members of the engineering profession, and most of all on a simplicity of operation which will enable any high school, not merely the large and well-equipped school, to take advantage of it. The last item is emphasized because 60 per cent of the high schools in the country, enrolling 40 per cent of the population, have 200 or fewer students. They are lacking courses, staff, and guidance specialists and yet enroll so considerable a number of desirable engineering candidates that it is fatal to neglect them.

1. The first step would appear to be a quota of students to enter engineering based on stable rather than emergency needs, and on the reasonable supply of such students in view of all the circumstances mentioned above. It is assumed that no quota established in this way can

possibly allow for a 50 per cent drop-out rate.

2. Engineering institutions should examine their admission procedures to make them better selection devices, in cooperation not merely with schools with good guidance programs, but also with schools which need much assistance in arriving at suitable criteria. They should make a rigorous examination of internal causes for drop-out, with some fixed objective of reducing the drop-out rate by a considerable percentage within a period of time. This undoubtedly would require the provision or the expansion of student personnel programs in all institutions.

3. The valuable work of the Guidance Committee of E.C.P.D. should be extended. Essentially the plans of this Committee consist of 3 items: The establishment of evaluative criteria in specialized subject matter and in personal characteristics, the furnishing of professional information about engineering, often referred to as "guidance material"; and enlisting the services of members of the profession in the areas of local high schools to furnish personal advice to young people, singly or in groups, who are investigating engineering as a profession.

One of the weaknesses in this program is the inability of many schools to take advantage of it. They do not have or cannot administer and interpret the standard tests involved. Their records do not supply cumulative information about their pupils activities from which their attitudes and habits of thinking may be estimated. They do not have a skilled counselor able to prepare the way for, or to supplement, the information and counseling supplied by the local engineer. They may even lack one or two of the courses essential in engineering preparation, and may be unwilling or unable to adopt emergency measures such as correspondence courses or unorthodox class room groupings, to supply these lacks.

4. Efforts should be made to insert into the curriculum essential facts about the importance of engineering in the prosperity and happiness of the world. A better understanding of the function of engineering in realizing the ideals of the United Nations, UNESCO, of the foreign-aid program, and of the defense against the common enemy should be sought. This, it should be understood, is not a guidance problem, but an instructional problem.

5. A concerted attack should be made on the resources offered by the boys in the small high school who are unable to obtain advanced mathematics or science course. The evidence mounts that lack of training in specific subject matter fields is a relatively unimportant factor in the success of students in colleges. Quality work and other evidences of ability and character in high school are far better auguries of success in college than the passing of an elaborate group of required units. A recent study at the University of Michigan not only established these facts, but also that the size of a high school from which a student graduates offers no correlation with his success in that institution. The candid waiving of certain subject matter preliminaries in the case of able students to whom they are unavailable, even at the expense of teaching them these elements after their arrival on the campus, would probably result in an appreciable addition to the number of acceptable freshmen in engineering classes.

6. Some better means for the placement of young engineering graduates and the protection of their job and employment rights should be a common objective of the engineering profession. Disturbing reports of some ruthless practices involving the hiring of more young graduates than the corporation needs, with the deliberate but unannounced purpose of reducing the number by the end of the year, have appeared. The immediate closing down or the reduction of experimental and research staffs at the slightest subsidence in business activity, leaving young engineers without jobs and often without homes, but with beginning families, should be examined. The reason for the rapid fluctuations in the ratio between engineers

and production workers should be looked into. Any widely advertised estimates on the demand and supply of engineers, whether they err on one side or the other, should be subject to much greater scrutiny if they are to avoid giving the public the idea that engineering is an unstable profession. All of these suggestions are more in the form of questions than of statements, the answers to which may prove that the implied criticisms are without foundation. It cannot be denied, however, that to an outside observer a determined effort to remove the causes even of the unfounded rumors should be made in the interests of helping young people to arrive at decisions about engineering as a career.

Conclusion

In conclusion it should be said that the engineering profession will meet with eager cooperation from high schools, their teachers, and their counselors. They will welcome any opportunity to replace the vague aspirations of young people seeking a profession with sure grounds for an adequate choice in a career with specific goals, even if these do not promise to lead to the end of the rainbow. The schools recognize their own weaknesses in their present handling of these situations. They will welcome any aid, whether materials, personal assistance, or professional advice, to help their young people. They know as well as any that the welfare of a profession depends upon the welfare of each member, and the productivity of a worker at any level is to a large degree the result of his reasonable adjustment and of satisfactions often measured in imponderables.

Centennial Issues of the Journal of Engineering Education

The December and January issues of the JOURNAL OF ENGINEERING EDUCATION will contain papers which were presented at the Centennial of Engineering in Chicago in September. Extra copies of these issues can be obtained for $1.00 per copy by writing to the American Society for Engineering Education, Northwestern University, Evanston, Ill.

Teaching Aids for Heat Transfer and Thermodynamics

By W. J. KING

Professor of Engineering, University of California at Los Angeles

During the spring of 1951 the writer undertook to canvass a representative group of engineering schools throughout the country in an attempt to discover what sort of aids were currently being used in teaching heat transfer and thermodynamics. As far as he was able to determine, very little of anything in this category is being employed in the classrooms. Following is a list of the gleanings from this survey:

Films

Professor McAdams, of M.I.T. has a film on "Visual Studies in Boiling," showing the formation of vapor bubbles on a heated surface. Mr. A. C. Mueller, of du Pont, has similar films on boiling heat transfer.

Professor Alan Colburn, of Delaware, has several films of heat transfer in heat exchangers, including tubular oil coolers.

C. F. Braun Co., Alhambra, California, have similar films of the action in heat exchangers.

Combustion Engineering-Superheater Company have an interesting colored film of combustion in the furnace of a large boiler.

Dr. E. Eckert, of the Power Plant Laboratory, Wright Field, Dayton, Ohio, has a film of interferometer studies of free convection in air. Mr. C. Coulbert, of U.C.L.A. has a similar film.

Models

Professor C. O. Mackey, of Cornell, has developed a hydraulic analog for demonstrating transient flow of heat, representing temperature in terms of the head of liquid standing in a series of small glass tubes, and heat in terms of rate of flow of the fluid.

Mr. A. J. Jackson, of Corvallis Heights, Oregon, advertised a remarkable transparent model of a 4-cycle engine, with hand-crank for rotating the shaft and exhibiting motion of all components, priced at $27.00. This was imported from abroad, and he anticipated that "other transparent machines and common engineering equipment may soon be available."

The Econolite Corporation of 3517 W. Washington Blvd., Los Angeles 18, California, manufacture a variety of animated, illuminated translucent colored charts, some of which show the action of various types of boilers and furnaces. These displays are quite striking and although developed originally for commercial advertising they should be quite effective as teaching aids, especially if adapted to illustrate the fundamentals of heat and thermo.

Charts

The W. M. Welch Manufacturing Co., of 1515 Sedgwick Street, Chicago 10, Illinois, distribute an excellent series of charts on chemical, physical and metallurgical subjects, including an elaborately illustrated 64 × 42 inch chart of Electromagnetic Radiations, edited by A. H. Compton. This chart shows very graphically how thermal radiations fit into the spectrum, and relates all forms of radiant energy to a great variety of phenomena

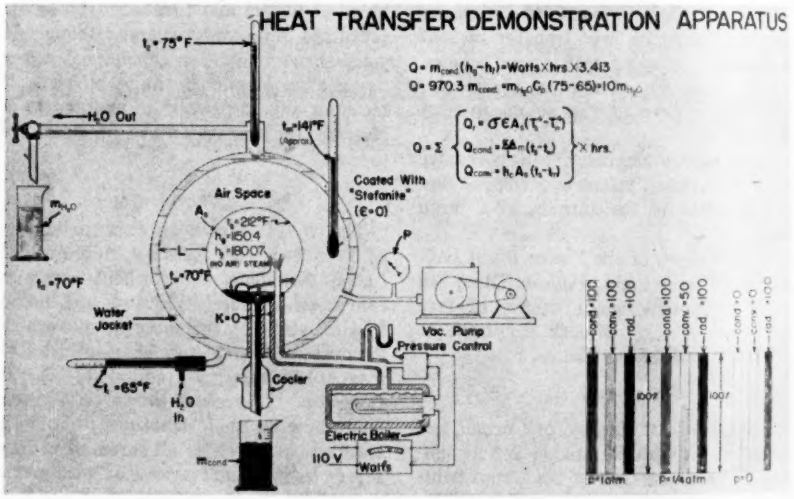
and apparatus. The Welsh Company expressed an interest in publishing special charts on other subjects "if the quantities would be 200 or more."

Suggestions for New Teaching Aids

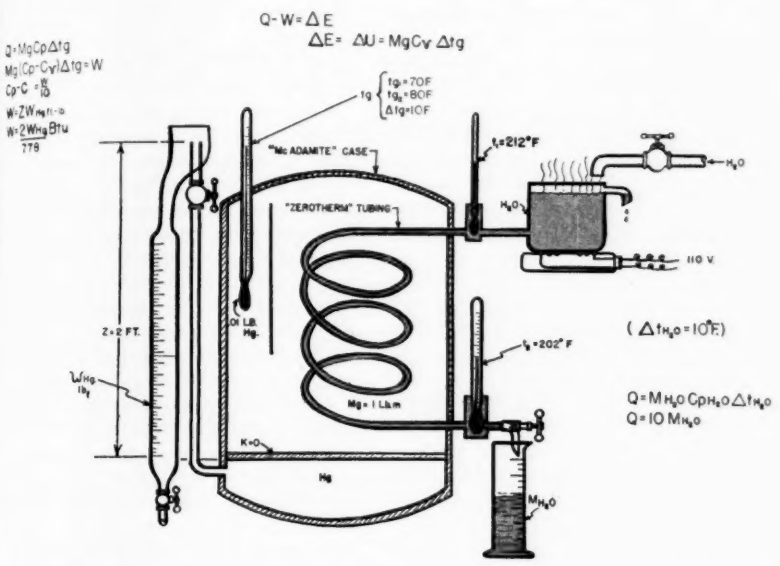
Some time ago the writer became interested in constructing demonstration models for use in the classroom to illustrate some of the fundamentals of heat and thermodynamics. In considering the design of such apparatus it soon became evident that the inadequacy of available materials would make it very difficult to show the students what was going on inside, during the demonstration. Even if the interior could be observed through transparent walls or windows, the heat flow could not readily be confined to the desired channels and media. Heat has a notorious tendency to leak or radiate in all directions, and the thermal conductivity of the best insulators leaves much to be desired. It was therefore finally decided to circumvent all of these difficulties, together with most of the expense, by constructing "two-dimensional appartus," in the form of large charts, employing special materials "invented" for the purpose.

Two of these charts are shown in the accompanying photographs.

The Heat Transfer Apparatus is designed to demonstrate the effects of pressure upon the conduction, convection and radiation of heat across the air space between two concentric spheres. The inner sphere, of thin-walled metal, is uniformly heated to 212 F by pure steam supplied by an electric boiler regulated to hold the pressure at 1 atmosphere. Boiler jacket and transmission losses are obviated by lagging all hot surfaces with a material having zero thermal conductivity ($K = 0$) and the tubing between the inner and outer spheres is made of this same material. The total heat flow (Q), across the air space is thus equal to the mass of condensate ($M_{cond.}$) collected in the lower graduate during any interval of time, multiplied by the latent heat of the steam ($h_g - h_f$), and is also equal to the watt-hrs. input to the boiler $\times 3.413$. All of this heat is absorbed by the cooling water jacketing the outer sphere, and is equal to ten times the mass of water collected in the upper graduate. (All three of these values of Q are measured during each run and any lack of agreement in-



FIRST LAW DEMONSTRATION APPARATUS



dicates faulty operation of the apparatus. Thus far no trouble at all has been experienced.)

The thermometer for measuring the mean temperature of the air (t_m) is coated with "Stefanite," a secret new material having an emissivity, or absorptivity, of zero for all radiations. The convection component, $Q_{conv.}$, could if desired, be measured in terms of an overall coefficient, a mean surface area, and the overall temperature difference ($U_c A_m (t_s - t_w)$, instead of $h_c A_s(t_s - t_m)$).

The apparatus is initially operated with atmospheric pressure in the air space. The conduction, convection and radiation components of Q are expressed as 100%, severally, as shown in the graph at the lower right. The vacuum pump is then started up and the air space pressure is reduced to ¼ atmosphere. At this point the conduction and radiation components remain unchanged, but the convection has been reduced to half of its original value. The original magnitude of the convective heat flow can then be found from the relation: $Q_{conv.} = 2(Q_{1\ atm.} - Q_{1/4\ atm.})$. The air pressure is now reduced to zero, which eliminates both the convection and the conduction, leaving the original radiation still unchanged. The initial conduction component can then be computed from: $Q_{cond.} = Q_{1\ atm.} - (Q_{conv.} + Q_o)$. These results check remarkably well with the values for the components computed from the three formulas above the vacuum pump, using appropriate values for ϵ, K, and h_c.

The Problem

The First Law Apparatus demonstrates the significance of C_p and C_v in operational terms and illustrates an elementary energy balance. The problem here was to make sure that all of the heat lost by the hot water in passing through the coil of tubing was delivered only to the one pound of gas trapped within the tank. If the tank case were made of any ordinary material it would absorb or trans-

mit more of the heat than was added to the gas, necessitating a large and uncertain correction in computing Q. The mercury in the bottom of the tank would likewise soak up a lot of the heat. This problem was solved very satisfactorily by constructing the tank of "McAdamite," the new hypothetical material having zero thermal conductivity and named at this point in honor of Professor McAdams of M.I.T. A liquid form of McAdamite was used to cover the surface of the mercury.

For measuring C_p the apparatus is operated as follows: Starting with an initial gas temperature of about 65 F and with the valve in the mercury vent tube open, the needle valve at the lower right is adjusted to pass water at such a rate that its temperature will always drop exactly 10 F between the two thermometers. At the instant when the gas temperature, t_g, reads 70 F a reading is taken of the amount of mercury in the graduate at the left and the amount of water in the graduate at the right. The same readings are taken when the gas temperature reaches 80 F. From the differences, the weight of mercury (W_{Hg}), and the mass of water (M_{H_2O}) are computed and used to obtain the values of Q and W, as shown in the chart. Then, $C_p = Q/10$ and $C_v = C_p - W/10$ (where W = total work done in lifting the Hg through the 2-ft.-height).

The value of C_v can be measured directly from $Q/10$ by repeating the experiment with the mercury vent valve closed. Agreement between the two methods has always been within less than .01%, which is considerably better than is usually obtained with other types of apparatus. (A slight correction must be made for the heat capacity of the thermometer and its silver-foil radiation screen.)

This kind of "apparatus" may be used quite conveniently in the classroom. It has the advantages of being fully transparent, readily portable, relatively inexpensive, very quiet and economical in operation, and requiring no appreciable maintenance. Yet it illustrates the principles quite lucidly, and can even be used in the laboratory by students who may be asked to obtain (hypothetical) test data from it!

* * *

ERRATUM

Apologies are due Professor V. M. Faires of North Carolina State College whose name was inadvertently omitted from the published list of the members of the Committee on Improvement of Teaching. The Report of this committee was published in the September issue of the JOURNAL OF ENGINEERING EDUCATION.

The Use of Films as "Outside Assignments"

By HARVEY WILKE

Associate Professor of Sanitary Engineering, Purdue University

The civil engineering curriculum of most engineering schools includes a course or courses in Water Supply and Sewerage. Unless special sanitary options or technical electives are available, it is frequently the students' only contact with the problems of sanitary engineering. The content of such courses in Water Supply and Sewerage generally includes the hydraulics of water distribution systems, water treatment processes, design of sewage collection systems, and sewage treatment processes—usually it is a senior course.

Unfortunately, there are always many of these senior students who have never visited a water plant or a sewage plant. Furthermore, the students who have visited such plants do not always possess an appreciation of the processes involved, the equipment used, etc. After all, it is difficult to know the design features of equipment submerged by water or sewage, or housed in sealed structures. Although some inspection trips include visits to a water plant and a sewage plant, it never is as comprehensive as might be considered desirable.

Recognizing that a certain amount of descriptive material is essential to the proper understanding and comprehension of water and sewage treatment processes, an experiment was tried in which the students had opportunity to view motion pictures and slides pertaining to the subject material of our *Water Supply and Sewerage* course. The films that are used either supplement or emphasize the lectures and text assignments. These films constitute one hour per week and are designated an "outside assignment." During the fall semester, 1951, they were shown twice each week, Thursday at 2 P.M. and Friday at 2 P.M. to provide all students an opportunity to get to one of the showings.

Purdue's *Water Supply and Sewerage* course consists of three class periods and two two-hour design laboratory periods each week—total credit of 4.3 units.

Capabilities and Limitations

It might be well to review briefly some of the capabilities and limitations of films for college instruction. To begin with, many films are limited in their ability to develop the students' reasoning or thinking powers. On the other hand, for a subject of this nature, a certain amount of basic imagery is necessary to comprehend design requirements of equipment or structures. They give the student a pseudo-experience. They also provide a vivid imprint on the student's memory. To be more specific, here is what films can do for a course in water supply and sewerage:

1. They can show complex details of water and sewage treatment operations. By animation these processes are capable of being viewed in stepwise developments.
2. They illustrate fundamental relationships between water, sewage, and the health of a community.
3. They can picture water source problems—somewhat like an immensely expanded inspection trip covering both time and space.
4. They can show microscopic organisms which cause water borne dis-

eases and which are utilized in biological treatment. This would otherwise take long laboratory periods and tedious microscopic work.

5. They can demonstrate techniques and methods of distribution system and sewage collection system installation —the "how it's done" type of picture.

If this can be accomplished as an "outside" assignment, then by the more traditional classroom procedures the theory can be developed to a far better understanding on the part of the student. The mental stage is set, curiosity is developed, and the instructor can go on to a full understanding by classroom and laboratory problems.

Careful integration of the film material with classroom and laboratory material is essential. The films are not an end in themselves. In the one-hour presentations, each film is introduced calling attention to special features to observe, etc. An illustration may be stopped on the screen during the running in order to discuss or emphasize some point. Questions, comments, etc., terminate the showing. In some cases additional visual aids are employed after the films by exhibiting and discussing small models, cut-aways of equipment, samples, etc. Finally, the classroom and laboratory further develops the theories and technical phases that have been illustrated in the film material.

Some of the films are shown without using the sound track and, instead, my own commentary is given if it is necessary to substitute the technical for the more popular aspects. Incidentally, this does not mean other assignments are not made. Typical reading assignments, home problems, etc., plus the one hour of films, make up about 2 hours assignment and preparation work for every classroom hour. It does require some time and extra work on the part of the instructor. He must present the films twice. He must review possible new films for the series as this revision process must go on indefinitely. And a certain amount of getting-ready time is necessary.

Certain costs are also involved. Although some of our films are from the Purdue Film Library, others are rented or borrowed. Most of the commercially produced films have no rental fees. Mailing, insurance, and rental fees for the program amounts to about $50.00 per semester.

Precautions

Some precautions are necessary. Regularity is important. If regular attendance is expected, "slip-ups" must be prevented. Promptness is essential. There have been occasions where a company has failed to send its film in time for a scheduled showing—several films that can be obtained on instant notice from our own library are available for such filling in. These films may be of only general interest and might lack some of the integration with the course and laboratory material, but such "slip-ups" do occur sometime and a filler is desirable.

Perhaps a yardstick by which to measure the usefulness of this program is the attendance figure and the attitude of the students. Attendance is voluntary and has average consistently ⅔rds of the 90 students enrolled this semester in the course. A few inevitably have work or class conflicts with both showings. A request for unsigned comments from ¼ of the enrollment showed that not one objected to the program—their comments ranged from just interested to very enthusiastic.

Report of Special Survey Committee

As your representative to the Special Survey Committee of the Engineers Joint Council the following is a report of a survey conducted by our Committee pertaining to the supply and demand of engineers which has just been completed.

Supply

Reports from 166 schools indicate that 27,813 first degrees were conferred during the period from July 1, 1951, ending June 30, 1952. It is, therefore, estimated that the total number of degrees given during the present academic year will approximate 30,000. These degrees were granted by accredited and non-accredited institutions. Of the schools surveyed 4,523 members are also receiving commissions in the Armed Forces. It is expected they will be called to active duty either immediately following graduation or shortly thereafter. This amounts to 16¼%. Of the group 1,266 or 4½% are enrolled members of the Armed Forces Reserves or National Guard, and 6,142 or 22% are vulnerable to Selective Service. There are 1,743 or 6¼% enrolled or seriously considering fulltime graduate study. Assuming, therefore, that there will be a very small loss or no loss at all to Selective Service, it is estimated that there should be available to industry approximately 22,000 to 23,000.

It is also interesting to note that the senior classes for 1952–1953 have an R.O.T.C. content of 22½%. The junior classes of next year represent an R.O.T.C. content of 45%, and the sophomore classes 55%. Although no concrete figures can be given, there is an indication that the mortality of the freshmen classes that entered last September, is lower than normal, which may be considered possibly as a hopeful sign.

Demand

The Survey Committee have also conducted a survey on the demand side of the picture. Replies from 326 companies and 32 governmental agencies have been received. A rough check of this information indicates a demand by industry of something over 30,000. This should not be considered as a firm figure as much checking has to be done in order to determine whether or not the information received from the companies and governmental agencies is representative. This check is being conducted at the present time and a report will be issued as soon as possible.

Respectfully submitted,

MAYNARD M. BORING, *Chairman*

A Plan for Training Women in Engineering

By FRED C. MORRIS

Department of Civil Engineering, Virginia Polytechnic Institute

For several months we have heard a great deal about the critical shortage of engineers. This information has come to us from all directions, newspapers, magazines, industrial bulletins, and the radio. It is variously estimated that the nation is short from 60,000 to 80,000 engineers. Based upon present college enrollment, there will be a severe drop in engineering graduates each year until those available for industry will almost reach the vanishing point in 1955. It is reported that there are some individual concerns now trying to recruit 1000 engineering graduates or more to meet their technical personnel requirements. This, of course, they cannot do because the graduates are simply not available. The Engineering Manpower Commission of the Engineer's Joint Council held a special meeting in Pittsburgh last September to try to find a solution to the problem. While no satisfactory solution has become apparent, the Commission has done a good job in letting the Congress and the public know of the seriousness of our plight.

The most important reason for our needing an adequate supply of engineers is, of course, the fact that we are engaged in a serious cold war with the communistic world. We do not know how soon this cold war might become a very hot war, the outcome of which will determine whether we will continue to enjoy our freedom or whether we will live in a state of virtual slavery. It is obvious, then, that the stakes in this conflict are very great indeed, and the freedom that we have fought for many times before could be snatched away from us. We should not underestimate the power of the 800 million people aligned against us, nor should we consider this a temporary emergency. Most likely, we are destined to face a terrific world population pressure for many years to come, and our freedom is secure only so long as we are able to successfully defend it. Our only hope in this direction is to maintain superiority in the field of technology; that is, we must always be prepared to meet the horde of manpower with overwhelming fire-power. In order to do this, we must not only keep the wheels of industry rolling at a high degree of efficiency, but we must at the same time advance technology. This is where the engineers come into the picture. Without their scientific knowledge, inventive genius, and technical know-how our American way of life would quickly be reduced to a pattern of life hardly worth the living. It is incumbent upon us all, therefore, to contribute as much as possible to the maintenance of our democratic form of government, each according to his talents.

Since it seems that the shortage of engineers may jeopardize our national welfare, the next question is what can we do about it. This is largely an educational problem, but it might be wise to approach it in the same manner that we would approach an engineering problem; that is, what results do we want and what do we have at our disposal to get these results. The basic facts in the case stack up something like this:

1. We are woefully short of professional engineers.
2. From 3 to 5 subprofessional workers are needed for each professional engineer.
3. Many professional engineers are doing subprofessional work because there is no one else to do it.
4. Most engineering colleges are not us-

ing their facilities to the maximum advantage because of the low enrollment.

5. There are many bright young women in college with inherent technical ability and many more graduating from high school each year.

6. While we lack an adequate supply of men for technical work, we do have a big untapped supply of women.

With these elements of the problem, it seems that the logical and intelligent thing to do would be to train women to do the subprofessional work in order to release the professional engineer for more important work. This would merely be doing the obvious, in which there is great virtue.

When the idea of using women in engineering work was proposed during the war, the engineers frowned with great misgivings. After the girls had worked for a while, however, the men discovered that they were really useful rather than just ornamental. The U.S. Office of Education operated the ESMWT short-course program for women, while some industries set up their own training program at a number of colleges. Many of the women who were trained during the war are still in engineering work and doing very well with it. In a speech made at the Virginia Polytechnic Institute on February 21st, Mr. Maynard M. Boring, Manager of the Technical Personnel Services Department of the General Electric Company, said, "Industry must make better use of women in technical work." The September issue of the *Scientific American* carried an article on mobilization prepared by Mr. Arthur S. Fleming, Assistant to the Manpower Director of the Office of Defense Mobilization. In the article Mr. Fleming made this statement: "In many professional and technical fields we shall not be able to solve our manpower problems unless we use women to a greater extent than we have up to the present time. To do so we must convince them that training for these occupations will give them an unusual opportunity to serve the nation during a very critical period."

Women have certain inherent characteristics which stand them in good stead. For instance, they are conscientious, they know how to use their hands, they are careful about detail, and quite important, they are not adverse to trying something new. Witness, for example, their proclivity to change the furniture around in the house about every three days to see if they can find a more efficient arrangement. This is exactly the procedure that our research scientists use; that is, if you don't know if something will work or not, try it and see. Quite often in scientific studies the going gets pretty rough and girls, being more sensitive and nervous than boys, sometimes become emotionally disturbed by overwork and the fear of failure. These troubles, for the most part, can be solved by the strategic use of a few kind words and a little human understanding. Girls will work their hearts out for you if you handle them right, which usually requires nothing more more than a sincere interest in their welfare. Even though girls will work very hard, they should not be accepted indiscriminately for engineering. If the use of women in technical work is expanded, every effort should be made to identify and interest only those who have shown distinct technical ability.

Since industry needs technical workers, and since the colleges have the facilities to train them, it seems that a working arrangement could be made that would be beneficial to both. For instance, it would not be at all difficult to incorporate one full year of engineering studies into the general science degree for those who want it, nor would it be impossible to do the same for those in home economics. This would involve credit hours only slightly greater than the number usually permitted for elective courses. Each college making this arrangement would have to work out the details of the course of study to fit its own local situation but, purely as a suggestion, the program might look something like this:

1. Mathematics to include College Algebra and Trigonometry.

2. One full year of Engineering Drawing.

3. One full year of Engineering Problems involving 12 hours per week of laboratory computations. This course would be designed to teach students how to apply fundamental principles to practical problems of the types most likely to be encountered on the job.

4. Other subjects to be studied might well be Freehand Sketching, General Physics, Materials of Engineering, Manufacturing Methods, and perhaps, Engineering Economics.

If a group of girls were studying to go to work in a particular industry, then the course of study could be designed to fit the needs of that industry.

Now let us see how this program would operate, what advantages it has, and what benefits might reasonably be expected from it:

1. Engineering colleges are already offering the courses that would be needed except the laboratory computations course in Engineering Problems. This course, however, would not be at all difficult to set up.

2. It would not be necessary to depend upon federal grants of money to operate the program. Students would merely pay the regular college fees as usual.

3. The full year of engineering would give the students much better preparation than the short-course type of 10 to 15 weeks which were run during the war.

4. It would help to accomplish our prime objective of supplying sub-professional workers to relieve professional engineers for more important work. These girls could take care of such things as drafting, production illustration, computations, time and motion studies, statistical work, and a multiplicity of other things of a similar nature. Also, a girl could act as an aide and understudy to a professional engineer. This would relieve him of the routine work and, at the same time, give the girl an excellent opportunity to expand her knowledge of engineering.

5. A qualified high school graduate could take the one year of engineering and go to work immediately. For a small investment of time and money she would be prepared to earn a good salary and could then use these credits later toward a degree.

6. Girls now enrolled in college could take the one year of engineering at the most convenient time for them; that is, the second, third, or fourth year. It might be possible to make arrangements with liberal arts colleges for interested seniors to transfer to engineering colleges for their fourth year of work. This would be particularly desirable for those who are majoring in Mathematics, Physics, and Chemistry.

7. Graduates in Mathematics and Physics might want to take engineering work during a fifth year in college, in which case it might be possible to design a program of study for them at a level that would justify the granting of a master's degree. If this is done, it would probably be better for individual industries to recruit these girls, perhaps from 25 to 100, and have the work designed to meet the needs of the industry. Based upon the number of students now enrolled in colleges and the anticipated need for technical personnel, industry can start now to prepare for the time when they will not be able to get enough engineering graduates to meet their requirements.

8. If the girls who take one year of engineering and work in industry for a while decide to go into educational work, they would make excellent science teachers for high schools. This experience would provide the background for teaching that many teachers do not have at present.

It would seem that the benefits mentioned in the foregoing should be sufficient justification for the serious consideration of a program to give young women a full year of training in engineering. In order to put a program of this nature in operation, the chances are that some inhibitions would have to be thrown overboard. This may be painful, but not fatal. The exercise of initiative, ingenuity, and some cooperation on the parts of the colleges and industry should contribute much toward relieving the critical shortage of engineers.

Options and Ornamentalities *

"Abridged"

By A. G. CONRAD

Chairman, Electrical Engineering Department, Yale University

Many years ago, I asked my predecessor, Charles F. Scott, why he was so insistent that his staff attend the SPEE meetings. He replied that it offered great opportunity for us to "listen to the deans and department heads tell about what a good job they are doing—particularly in playing checkers with the curriculum." It seems particularly fitting and historically correct for this meeting to have a couple department heads carry on this tradition and to recommend to you the proper proportions of the educational menu called the electrical engineering curriculum and to specify the content of these more choice morsels, commonly called options.

As outlined earlier by our chairman, my participation should be limited to a discussion of the power option only, and the communication option should be left in the more competent hands of my good friend, Professor Ryder. Then after Professor Ryder and I have exhausted our energies in attempting to prove to the world the vast importance of these two particular options, the third member of our panel will toss into the meeting a lighted firecracker which shall terminate some of the nightmares of academic confusion, clarify the objectives of the curriculum, and standardize our electrical engineering programs along lines consistent with accepted Gallop Poll opinions as of 1951.

There is nothing sacred about a curriculum, and therefore nothing sacred about an option. Both are set up to facilitate organization, administration and records. No direct educational benefits are derived from either. The curriculum of the very best and the very poorest schools can look exactly the same on paper, just as the menu at the Waldorf could list precisely the entries on the menu at "Joe's Beanery." There is a vast difference between the intellectual nourishment derived from a well organized, competent faculty and that obtained from a weak staff. Yet the curricula in which these staffs operate may be identical. A curriculum, like a menu, is nothing more than a list indicating order of service with no guarantee of quality. A curriculum is not indicative of the quality of the institution, competence of the instructor, adequacy of mental or physical facilities, or a guarantee of a valid education.

The undergraduate curriculum in electrical engineering has been in a continuous state of revision. Some recent revisions undoubtedly resulted in improvements—others are of little consequence or may be detrimental. The surest method of starting a new curriculum is to appoint a new department head. Too frequently administrators resort to *making a change and calling it an improvement.* I, for one, feel that changes in a curriculum without changes in the teaching staff will cause little change in the effectiveness of any program. A curriculum, no matter how well organized, can never be better than the teaching staff that administers it. A perfect listing of undergraduate courses without a competent teaching staff can look good in the catalog, but in reality,

* Presented at A.S.E.E. meeting, East Lansing, Michigan, June, 1951.

it is only an educational ornamentality. Throughout American education there have appeared annually many catch phrases which, through publicity, attract attention. Twenty years ago, this organization was shouting about "creative thinking" and a few of our leading educators seemed to have, in their own opinion, a monopoly on this supposedly novel objective. The rage subsided and we haven't any proof that the whole thing was anything more than an educational ornamentality.

In following years, educators spent much time on the so-called Comprehensive Examinations. Interest in this supposedly novel feature died rapidly when we became aware that such examinations have not contributed greatly to the competence of the graduate and that these examinations were, in many cases, just other educational ornamentalities.

Several years ago, a new crop of curricula sprung up under the name of Engineering Physics. Some of the programs were of high quality. Others consisted only of a common physics program with a maximum of two elementary engineering courses, such as engineering mechanics, inserted in place of some electives. Such programs are not engineering-physics. They are certainly not engineering. While they may look good in the catalog, in reality, they fall into the category of ornamentalities.

I do not wish to imply that all of these innovations and experiments with the curricula have been failures. The cases where they have produced greatest success are undoubtedly those associated with a competent teaching staff. Any program left in the hands of an incompetent faculty results in a failure, regardless of its organization.

Perhaps these comments seem irrelevant to the subject under discussion. They are not intended as such. Neither are they intended to belittle the ideas expressed by other members, present or past, on suggested change in electrical engineering programs. Change is always necessary, and without change, progress is impossible. It should be remembered by all of us that a change does not guarantee improvement; and that the recommendations of A.S.E.E. speakers quite frequently possess a novel appeal, but that they have no enduring value and eventually fall into the class of educational ornamentalities.

The organization of a good teaching staff is far more important that the organization of options. A good faculty is the greatest asset of a university. A poor faculty produces nothing but liabilities—financial and mental. Certain options in a university curriculum may be very successful in institutions where proper staff and facilities are available. If these facilities and educators are not available, any attempt to offer such options will result in nothing more than catalog ornamentalities.

Report of the Vice President for Instructional Division Activities

It has been customary for the vice president for instructional activities to summarize in his annual report the instructional activities of the past year. His responsibility is stated to be the activities of the Committees and Divisions and he has also been given a general responsibility for the program of the Annual Meeting and for the Summer Schools. However, the Secretary will cover all of the current activities adequately in his report and therefore it seems more useful for your vice president to give his attention to an analysis of the effectiveness of our activities with a view to determining directions for improvement.

The Divisions

The twenty-one Divisions of the Society were first credited with bringing it a new life and were later criticized for having reduced the general interest of the Society in discussions of pedagogy. Both are probably true statements. The growth of the Divisions beginning in the nineteen-thirties coincided with a growth of the Society for which they were doubtless in part responsible. Most engineering teachers have not studied courses in education. Accordingly, their interest in education or pedagogy is directly associated with subject matter. In talking about principles in education they invariably use illustrations from subject-matter fields. Hence, for the mere purpose of communication they choose to group themselves under subject-matter divisions. Thus the original Divisions were born, and in this lies their strength. A few non-subject-matter Divisions such as Cooperative Engineering and Relations with Industry exist for obviously different purposes.

The question to be raised is whether the multiplicity of Divisions should be encouraged or discouraged. The writer was involved in the formation of two Divisions and he recalls vividly the enthusiasm engendered at that time and the heavy attendance at the early sessions sponsored by these Divisions. Despite the doubling of our membership in about a decade, sessions appear to be smaller rather than larger. Attention may be called to the fact that despite a 100 per cent increase in membership the largest meeting held by the Society was not in 1950 or 1951 but was in 1939 at the Pennsylvania State College.

It could be very important to the future of ASEE to re-develop the original enthusiasm created by the formation of the Divisions of the Society. Certainly this cannot be done by discouraging the formation of new Divisions or by eliminating those that exist, although there should be no hesitancy in eliminating any Division that becomes lifeless and unable to conduct its proper activities. The immediate need is to bring the Divisions into the forefront of Society activity and this can be done by working through them in matters of general Society affairs.

As an example of an enlivening influence upon the Divisions let us consider the plan to produce a study or evaluation of engineering education during the next two or three years. It will be a stimulating influence to have the Divisions associated with this study. Since an institutional committee will be appointed on each campus, it is reasonable to assume that each institutional committee will have at least one member who is a mechanical engineer. If these mechanical engineers

who are engaged in the evaluation of engineering education on many campuses can be contacted by the Mechanical Engineering Division, they can be organized within the framework of the Division for active exchange and correlation of information. The same would be true for most Divisions of the Society. The result should be better committee work at the institutional level and a great stimulation of Division activity.

The Committees

The Society has two kinds of Committees, standing committees and task committees. Task committees are appointed to accomplish a given task, and as soon as the task can be reasonably accomplished the task committee should be promptly discharged. Rotation of membership is therefore not normal in a task committee. In contrast, a standing committee provides an opportunity for rotation of membership that builds interest and morale in the membership of the Society. Each year all standing committees need to be studied from the viewpoint of their continued usefulness to the Society. Inactive committees are corrosive since the membership considers such appointments to be an undeserved honor. An annual report should be required from every committee to justify its continuation.

The Summer Schools

Three or more summer schools have been conducted each summer for the past three years. Before that, a single summer school only was sponsored. The evidence is quite conclusive that the new plan is serving more persons in a very useful manner. The present type of informal summer school is an expansion valve for the annual meeting. Any ambitious group can plan a summer school either in association with or at a different time and place than the annual meeting. The only requirement that needs to be maintained is that the summer school really concern itself with engineering education and not become a research seminar. It must also maintain a balanced budget with a registration fee limited by Council action to $1.50 per day. These regulations have been followed without complaint.

It is believed that the present plan for the conduct of unlimited informal summer schools should be continued and that the Society should leave to the Divisions and Committees the initiative in this matter. The summer conference sponsored by the Committee on "Improvement of Teaching" conducted at Schenectady with Council approval through the cooperation of the General Electric Company is an experiment that will deserve study. Certainly the ASEE desires the closest relations with industry and should invite such cooperative arrangements when the objective is clearly, as in the present instance, a desire on the part of industry to aid in the education of engineers.

The Annual Meeting

Those who feel that our Society has lost some of its interest in the discussion of educational problems on a non-subject-matter basis should study the program of the annual meeting. Before the establishment of the ECAC and ECRC three general meetings were frequently devoted to such educational discussions. For the past two years the only part of the program that might be considered to be of this nature has been the President's address and a brief report from the "Committee on Improvement of Teaching."

If the Council should feel seriously about the need for stimulating general discussions of teaching and of engineering education on a non-subject-matter basis, it should decide that a new type of program for the Annual Meeting is in order. Such a program might provide alternate general meetings to those of ECAC and ECRC or it might increase the number of general meetings. A plan by which each morning from Monday through Thursday would be devoted to one or to two nonconflicting general sessions with afternoons and evenings given to the Divisions and Committees would lend a considerably different character to the Annual Meeting.

In this final annual report I wish to ex-

press my appreciation for the opportunity to serve the American Society for Engineering Education during the past two years. Only the officers have the opportunity to observe the time and attention given by so many individuals to the work of the Society. It must be that these individuals consider it to be "their Society" in the best sense of that expression. It is always a pleasure to be a part of such an organization.

Respectfully submitted,

L. E. GRINTER,
Vice President for Instructional Division Activities

Report of Vice President in Charge of Sections and Branches

Sectional activities in the Society have been excellent during the past academic year, and a large portion of the meetings have been attended by various members of your Executive Committee.

As indicated at the Council meeting held at Houston, Texas, shortly before the first of the year, practically all of the Sections have carried the theme of the annual meeting concerning the development of more intimate contact with the faculty of the secondary schools of mathematics and science to encourage more qualified students to enroll in engineering and science. Apparently there have been good results from such a program as there are indications of a definite upturn in enrollment during this past year.

All of the Sections have been alerted to the present as well as the expected shortage of engineers during the next few years, and excellent panels, talks, and other discussions have resulted. The Sections have been encouraged during the past year to increase the participation of younger teachers in the Society, and your officers have found on visits to the schools that excellent work is being done by the young teachers. It is felt that encouragement of this plan is essential in preparing adequate leadership for future years of the Society.

Reports reviewed by the various Sections are stimulating and it is clear that our Society is in excellent shape. Many new members have been enrolled, interest in the Society is spreading rapidly and with continued good leadership, our Sections, wherein lies our real strength, are going to continue to help our Society meet its obligations.

Respectfully submitted,

M. M. BORING,
Vice President in charge of General and Regional Activities

Annual Report of the Engineering College Administrative Council

Officers and Committees:

The officers of the Engineering College Administrative Council for the year 1951–52 were: J. H. Lampe, *Chairman*; W. R. Everitt, *Secretary*.

Executive Committee Members were: W. T. Alexander, J. F. Downie Smith, M. A. Durland, H. E. Wessman, and J. H. Davis.

Committee chairmen were: International Relations, L. J. Lassalle; Military Affairs, William Allan; Secondary Schools, W. S. Evans; Selection and Guidance, H. Russell Beatty; Manpower, George D. Lobingier.

Executive Committee Meetings:

Three executive committee meetings were held during the year, the first in Houston, Texas, on November 15, and the second and third at the Cornell Club in New York City on January 24, 1952, and on March 7, 1952.

At the Houston meeting, W. L. Everitt was acting-chairman as well as secretary, due to the illness of Chairman J. H. Lampe. Matters discussed included: Professor Bronwell's Japanese Mission; the representation of ASEE in UNESCO; the program for the summer meeting, and organization of an ad hoc committee on relations with secondary schools.

The meeting of January 24 was attended by President Hollister and Secretary Bronwell of ASEE and Vice-president Lampe and Secretary Everitt of ECAC. Progress was made at this meeting on planning the program for the annual meeting at Dartmouth. Other matters discussed included work with secondary schools and guidance and counseling.

At the March meeting a number of activities were dealt with. A nominating committee was appointed to propose a slate for 1952–53 at the June meeting. Committee members included F. E. Terman, *Chairman,* and H. O. Croft and L. E. Seeley. Program details of the June meeting were discussed, and it was decided to limit the number of topics considered, in order to allow sufficient opportunity for full discussion. It was further decided to change the name of the "Closed Session" to "ECAC Session for Institutional Representatives" in order to avoid a wrong impression. No attempt would actually be made to exclude members not institutional representatives. In connection with the ASEE Program of the Year, the Committee explored the possibilities of an ECAC Committee on Junior Colleges and decided to expand the activities of the Secondary Schools Committee to include this phase of activity.

Projects of the Year:

The prime interests of the ASEE this year are summarized as follows:

1. Activities which would lead to and bring about scholastic improvement in engineering college programs and in teaching.
2. Activities leading to a fuller understanding of engineering educational programs, especially by means of the cooperation of high school teachers and engineering college teaching and administrative groups.

In order to further these section activities and to carry on overall programs, the ECAC, through its several committees, has carried out programs of study, made recommendations on the subjects concerned.

and developed programs for the national meeting.

News Bulletins:

During the past year the ECAC News Bulletin was circulated three times to our institutional, associate, and affiliate members, and to the ASEE officers and council members.

Respectfully submitted,

J. H. LAMPE, *Vice President*
Engineering College Administrative Council

Candid Comments

Secretary
A.S.E.E.
Northwestern University
Evanston, Illinois

Dear Sir:

As the interested mother of a young man who teaches engineering subjects, I often re-read articles in the JOURNAL OF ENGINEERING EDUCATION. I find this a really educational occupation.

Just this morning, in checking over old issues, I find in the April, 1949 issue a most unusual article by T. J. MacKavanagh, Catholic University of America. (I must admit that until this moment I did not note his connection with a religious institution.) The article is entitled "On Pussyfooting."

This article is much too good to be confined to a Journal which the general run of people do NOT see. For many years I have wished that some one would stir up some action of this sort in connection with the so-called institutions of "higher education." Freshmen come in at 17 or 18—most impressionable years—away from home for the first time, and regardless of any previous leaning toward what is called "religious training," they are tossed into classes where they are too often laughed out of any religious feeling. Mr. MacKavanaugh quotes from an article in the September, 1948 JOURNAL, page 10, "Words seem to be lacking to define the exact need we would fill—for we must not call it religion—so let us say an unpledged allegiance to HONOR, which Webster defines. . . ."

I can think of a number of retired teachers—professors emeritus—who could very well devote a part of their retirement to teaching an occasional class (elective) along these same lines. A thoughtful teacher MUST see just what is happening to young people who have no such "unpledged allegiance to honor."

Very truly,

JOSEPHINE SCOTT CAMPBELL,
Pasadena, California

Third National Surveying Teachers' Conference

The Third National Surveying Teachers' Conference was held August 3–8, 1952 at Camp Rabideau, Blackduck, Minnesota under the joint sponsorship of Committee VIII (Surveying and Mapping) of the A.S.E.E. Civil Engineering Division and of the University of Illinois. Delegates from more than fifty colleges of the United States and Canada discussed the teaching of surveying in today's engineering curriculum and heard papers by outstanding surveying teachers and representatives of governmental and private surveying and mapping groups.

E. C. Wagner reported the findings of a nationwide questionnaire survey which showed a breakdown of class hours devoted to various topics in the sequence of surveying courses, a helpful compilation for comparative study. The value of surveying to engineers, civil and non-civil, was affirmed in papers by Norman Porter and R. C. Rautenstraus.

A panel discussion on the requirements and demands for surveying in engineering education was conducted by M. B. Gamet. Panelists were: George H. Harding, Sol A. Baure, Robert C. Johnson, and L. O. Stewart.

The American transit was appraised by R. K. Palmer, and a new type tripod was revealed in a paper by John J. Durkin of the Engineering Research and Development Board to be in the final stages of the development. Sumner B. Irish offered several further areas in surveying that invite research in equipment, procedures, and technique, and urged that such projects be undertaken at once to keep pace with modern science. One such development, the use of electronic surveying equipment, was described by Commander Carl I. Aslakson, U.S.C.G.S. He predicted widespread use of trilateration to replace triangulation within a very few years with a high order of accuracy and with a great saving of time. Photogrammetry, the newest tool of the surveyor, and geodesy, one of the oldest and most necessary, were reviewed and their place in today's curriculum discussed. Papers on photogrammetry were presented by S. H. deJong and Leo V. Nothstine. The paper on geodetic surveying was given by M. O. Schmidt.

One of the more important matters, the teaching of surveying in the classroom and in the field, occupied the conferees during a day-long session. Audio-visual teaching aids was the subject of a paper by Kenneth S. Curtis, and Alfred C. Stiefel, speaking on "Ten Thousand Maps at Your Service," urged the teachers to acquaint surveyors and engineers with these available maps and demonstrate their great utility in solving many everyday problems. Excellent ideas were contributed to the subject of field instruction by Otto S. Zelner, while Fred J. Spry detailed the several methods in use throughout the nation's schools for the storage, handling, and care of surveying instruments and equipment. Many ideas were exchanged in the session devoted to field techniques conducted by Carl A. Egner.

The papers of the Third National Conference will shortly be published in a bound volume and may be procured from Professor Sumner B. Irish, Editor, at Princeton University at nominal cost.

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
*Allegheny	West Virginia University		C. H. Cather, West Virginia University
Illinois-Indiana	Rose Polytechnic Institute	May, 16, 1953	H. A. Moench, Rose Polytechnic Institute
Kansas-Nebraska	University of Kansas	Oct. 24–25, 1952	M. A. Durland, Kansas State College
Michigan	Detroit Institute of Technology	May 9, 1953	C. C. Winn, Detroit Institute of Technology
Middle Atlantic	Manhattan College	December 6, 1952	W. B. Plank, Lafayette College
Missouri	Washington University	April 11, 1953	G. F. Branigan, University of Arkansas
National Capital Area	Catholic University of America	Oct. 7, 1952	L. K. Downing, Howard University
	Howard University	May 9, 1953	
	University of Maryland	Feb. 3, 1953	
New England	Worcester Polytechnic Institute	Oct. 18, 1952	E. T. Donovan, University of New Hampshire
North Midwest	Iowa State College	Oct. 3–4, 1952	S. J. Chamberlin, Iowa State College
*Ohio	University of Cincinnati	April, 1953	H. K. Justice, University of Cincinnati
*Pacific Northwest	Washington State College	Spring, 1953	J. P. Spielman, Washington State College
Pacific Southwest	California State Polytechnic College	Dec. 29–30, 1952	C. E. Cherry, College of Marin
*Rocky Mountain	University of Wyoming	April 19, 1952	C. A. Hutchinson, University of Colorado
*Southeastern	Louisiana State University	March, 1953	D. V. Terrell, University of Kentucky
Southwestern	University of New Mexico	April 3 & 4, 1953	M. L. Ray, University of Houston
Upper New York	Alfred University	October 10–11, 1952	R. M. Campbell, Alfred University

Members of the Society are welcome at all Section Meetings

* No Date Set.

ASEE Committees, 1952–53

Associate Institutional Membership: J. C. McKeon, *Chairman*, Westinghouse Electric Corp., East Pittsburgh, Pa., H. K. Breckenridge, C. E. Davies, L. J. Fletcher, C. J. Freund, Keith Glennan, E. P. Hamilton, S. C. Hollister, W. N. Jones. Ex-officio: W. R. Woolrich, A. B. Bronwell.

Atomic Energy Education: For three years: L. M. K. Boelter, G. H. Hawkins; for two years: H. B. Hansteen, H. E. Wessman; for one year: H. H. Armsby, R. C. Ernst. Secretary: A. F. Thompson, AEC.

Constitution and By-Laws: H. H. Armsby, *Chairman*, U. S. Office of Education, Washington, D. C., L. A. Bingham, E. C. Easton, C. J. Freund, E. K. Kraybill, G. A. Marston, L. E. Seeley, L. F. Smith.

Engineering Economy: H. S. Osborne, *Chairman*, American Telephone & Telegraph Co., New York, N. Y., J. M. Apple, E. D. Ayres, J. C. Gebhard, E. M. Griswold, A. R. Gruehr, A. Lesser, J. F. Manildi, K. B. McEachron, Jr., W. D. McIlvaine, S. J. Montgomery, W. R. Spriegel, H. G. Thuesen, J. E. Vivian.

Engineering School Libraries: George Bonn, *Chairman*, The Rice Institute, Houston, Texas, J. E. Allerding, C. W. Bennett, W. S. Budington, E. A. Chapman, W. R. Harvey, Wm. Hyde, P. Leslie, C. Penrose, M. Ritchie, H. E. Sauter, V. D. Tate, I. A. Tumbleson.

Ethical Standards, Promotion of: C. J. Freund, *Chairman*, University of Detroit, Detroit, Mich., N. A. Christensen, N. W. Dougherty, E. F. Obert.

Evaluation of Engineering Education: L. E. Grinter, *Chairman*, University of Florida, Gainesville, Fla., H. H. Armsby, L. M. K. Boelter, A. P. Colburn, C. S. Crouse, J. P. Den Hartog, N. W. Dougherty, T. H. Evans, W. L. Everitt, R. C. Ernst, M. G. Fontana, D. F. Gunder, J. F. Gregg, G. A. Hawkins, S. C. Hollister, J. A. Hrones, L. H. Johnson, J. Marin, G. Murphy, M. P. O'Brien, R. L. Pigford, D. H. Pletta, R. S. Poor, J. H. Rushton, H. Rouse, T. Saville, H. H. Skilling, A. F. Spilhaus, R. L. Sweigert, R. B. Teare, E. A. Walker, E. Weber, H. E. Wessman, C. L. Wilson, A. Wolman, W. R. Woolrich, D. Young, A. B. Bronwell.

Financial Policy: F. M. Dawson, *Chairman*, State University of Iowa, Iowa City, Iowa, S. C. Hollister, Thorndike Saville, C. L. Skelley.

George Westinghouse Award: F. B. Seely, *Chairman*, University of Illinois, Urbana, Ill.; (retiring in 1956) Fred Pumphrey, B. G. Elliott; (retiring in 1955) G. W. Gleeson, H. Rouse; (retiring in 1954) H. P. Hammond, F. B. Seely; (retiring in 1953) N. A. Christensen, R. E. Vivian; N. N. Muller, ex-officio.

James H. McGraw Award:

Lamme Award: F. E. Terman, *Chairman*, Stanford University, Stanford, Calif.; (retiring 1956) George Granger Brown, Jess H. Davis, J. C. Warner; (retiring 1955) J. C. McKeon, R. L. Sweigert, F. E. Terman; (retiring 1954) M. M. Boring, M. P. O'Brien, B. R. Teare; (retiring 1953) N. W. Dougherty, W. K. Lewis, K. F. Wendt.

Membership: W. R. Woolrich, *Chairman*, University of Texas, Austin, Texas. *Institutional Chairmen:* G. H. Dunstan, W. D. McIlvaine, W. S. Wilson, M. L. Thornburg, A. S. Turner, G. F. Branigan, E. D. Howe, D. L. Trautman, A. Hansen, C. O. Terwilliger, F. Thomas, C. E. Knott, R. J. Smith, J. N. Goodier, W. C. DuVall, C. M. Knudsen, T. H. Evans, W. M. Richtmann, H. J. Reich, F. L. Castleman, L. W. Gleekman, T. J. MacKavanaugh, M. A. Mason, L. K. Downing, F. H. Pumphrey, C. L. Emerson, J. Hugo Johnson, E. R. Whitehead, F. W. Trezise, R. A. Klipphardt, R. E. Gibbs, S. H. Pierce, D. S. Clark, H. E. Ellithorn, H. A. Moench, F. Kerekes, C. J. Posey, T. D. Carr, C. S. Crouse, M. G. Northrup, L. J. Lassalle, G. L. Corrigan, G. G. Hughes, L. H. Johnson, A. S. Campbell, L. M. Kells, A. Wolman, W. J. Huff, G. A. Marston, W. T. Alexander, G. M. Fair, R. B. Finch,

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Cooperative Committee on Teac[illegible] Science and Mathematics: [illegible] O. Schmidt, C. E. Watson.

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Y10—Symbols and Abbreviations: W. A. Lewis, *Chairman*, T. C. Hanson, P. J. Kiefer, W. B. Plank, M. C. Stuart, C. C. Whipple.

Sub-Committee Z10.4–1943—Letter Symbols for Heat and Thermodynamics: B. E. Short, H. L. Solberg, M. C. Stuart.

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Y15—Graphic Presentation: R. S. Paffenbarger, *Chairman*, D. P. Adams, A. S. Levens, R. O. Loving.

Y32—Graphical Symbols and Drawings: I. L. Hill, *Chairman*, J. G. McGuire, R. T. Northrup.

A62—Coordination of Dimensions of Building Materials and Equipment: R. A. Caughey.

C61—Electric and Magnetic Magnitudes and Units: Harold Pender, C. V. O. Terwilliger, C. F. Rehberg.

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Engineers Joint Council:

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National Bureau of Engineering Registration: C. L. Eckel.

National Research Council: G. A. Rosselot (June, 1953).

National Science Foundation—Committee on International Exchange of Students: S. S. Steinberg.

National Science Teachers Association—Future Scientists and Engineers of America: H. R. Beatty.

New Members

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ANDERSON, J. GILMAN, Instructor in Building Technology, N. Y. State Agricultural & Technical Institute, Alfred, N. Y. G. S. Whitney, R. M. Campbell.

BAUGHMAN, CAVINS, Instructor in Training, Ford Motor Company, Dearborn, Mich. R. T. Northrup, H. M. Hess.

BERLETH, FRANCIS H., Assistant Chief Engineer, Hughes Tool Company, Houston, Tex. W. R. Woolrich, V. L. Doughtie.

BIECK, WALTER H., Associate Professor of Drafting, Milwaukee School of Engineering, Milwaukee, Wis. R. J. Ungrodt, F. Kaufmann.

BRIGGS, WILLIAM W., Assistant Professor of Air Transportation, Purdue University, Lafayette, Ind. N. Little, P. E. Stanley.

BROWN, JULIUS, Instructor in Engineering, St. Louis University, St. Louis, Mo. V. J. Blum, J. B. Macelwane.

CADY, JOSEPH G., Instructor in Mechanical Engineering, Syracuse University, Syracuse, N. Y. D. U. Greenwald, B. H. Norem.

CHIRLIAN, PAUL M., Instructor in Electrical Engineering, New York University, New York, N. Y. P. Greenstein, T. Torgersen.

CONNELL, JOHN B., Instructor in Engineering, St. Louis University, St. Louis, Mo. V. J. Blum, J. B. Macelwane.

CURTIS, ROZEL E., Staff Assistant, Technical Personnel, General Electric Co., Schenectady, N. Y. D. W. McLenegan, T. S. Marshall.

DOBBINS, WILLIAM E., Associate Professor of Sanitary Engineering, New York University, New York, N. Y. W. T. Ingram, T. Saville.

DRAPER, ALAN B., Instructor in Industrial Engineering, Syracuse University, Syracuse, N. Y. D. U. Greenwald, B. H. Norem.

DUNLAP, EUGENE W., Instructor in Engineering, St. Louis University, St. Louis, Mo. V. J. Blum, J. B. Macelwane.

FENNELLY, DENNIS M., Professional Placement Supervisor, Burroughs Adding Machine Co., Philadelphia, Pa. H. E. Tompkins, I. Travis.

GOODMAN, C. J., Instructor in Engineering, Detroit Institute of Technology, Detroit, Mich. L. L. Henry, E. A. Lucitte.

GRUEHR, ANATOLE R., Adjunct Professor of Economics, Polytechnic Institute of Brooklyn, N. Y. H. F. Roemmele, A. Lesser, Jr.

GUMPERTZ, WERNER H., Assistant Professor of Building Engineering and Construction, Massachusetts Institute of Technology, Cambridge, Mass. W. C. Voss, J. T. Rule.

HINKLE, WALTER C., Assistant Director, N. Y. State Agricultural & Technical Institute, Alfred, N. Y. G. S. Whitney, R. M. Campbell.

IERARDI, GORDON S., Associate Editor, John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y. W. B. Wiley, W. G. Stone.

KELLY, SIDNEY J., Head, Diesel Technology, N. Y. State Agricultural & Technological Institute, Alfred, N. Y. G. S. Whitneym R. M. Campbell.

KLINE, JACOB, Assistant Professor of Electrical Engineering, University of Rhode Island, Kingston, R. I. R. H. Frazier, C. E. Tucker.

KNUDSEN, JOHN R., Assistant Professor of Mathematics, New York University, New York, N. Y. H. A. Giddings, G. A. Yanosik.

KOLSTAD, CHARLES K., Instructor in Diesel Technology, N. Y. State Agricultural & Technical Institute, Alfred, N. Y. G.S. Whitney, R. M. Campbell.

LANE, JOHN D., Professor of English, Clemson, S. C. J. H. Sams, J. L. Edwards.

LAWLOR, JAMES J., Instructor in Machine Design, Stevens Institute of Technology, Hoboken, N. J. M. R. Reeks, N. J. Rose.

LINGO, LOWELL E., Instructor in Electrical Engineering, Syracuse University, Syracuse, N. Y. D. U. Greenwald, B. H. Norem.

LIPPERT, FREDERICK G., Director of Personnel, American Gas and Elec. Service Corp., New York, N. Y. D. S. Roberts, F. D. Leamer.

LOBDELL, LEON W., Instructor in Industrial Engineering, N. Y. State Agricultural &

Technical Institute, Alfred, N. Y. G. S. Whitney, R. M. Campbell.

LONG, RALPH H., JR., Associate Professor of Mechanical Engineering, University of Maryland, College Park, Md. J. E. Younger, M. S. Ojalvo.

MCGOWAN, JOHN P., Engineering Librarian, New York University, New York, N. Y. F. K. Teichmann, A. H. Church.

MEIXNER, HENRY N., Assistant Director, Machine Develop. Section, E. I. duPont de Nemours & Co., Inc., Wilmington, Dela. T. H. Chilton, R. E. Burton.

MULLIGAN, JAMES H., JR., Associate Professor of Electrical Engineering, New York University, New York, N. Y. H. Torgersen, P. Greenstein.

PAGE, GEORGE N., Assistant Professor of Engineering Drawing, Syracuse University, Syracuse, N. Y. D. U. Greenwald, B. H. Norem.

PANTER, HAROLD J., Instructor in Electrical Engineering, N. Y. State Agricultural & Technical Institute, Alfred, N. Y. G. S. Whitney, R. M. Campbell.

PARKER, JAY B., Assistant Professor of Civil Engineering, Rensselaer Polytechnic Institute, Troy, N. Y. H. O. Sharp, R. K. Palmer.

PATNODE, WINTON I., Assistant to General Manager, Nucleonics Division, General Electric Company, Richland, Wash. D. W. McLenegan, T. S. Marshall.

PATCHEN, LEWIS W., Instructor in Industrial Engineering, N. Y. State Agricultural & Technical Institute, Alfred, N. Y. G. S. Whitney, R. M. Campbell.

RENNER, JOHN H., Instructor in Electrical Engineering, N. Y. State Agricultural & Technical Institute, Alfred, N. Y. G. S. Whitney, R. M. Campbell.

RISING, EDWARD J., Instructor in Mechanical Engineering, Syracuse University, Syracuse, N. Y. D. U. Greenwald, B. H. Norem.

RITTER, LEO J., JR., Associate Professor of Civil Engineering, University of Florida, Gainesville, Fla. T. L. Bransford, W. H. Zimpfer.

ROCKEY, CHARLES F., Instructor in Electrical Engineering, Milwaukee School of Engineering, Milwaukee, Wis. F. J. Van Zeeland, F. H. Kaufmann.

SCOTT, MARION B., Associate Professor in Structural Engineering, Purdue University, West Lafayette, Indiana. P. E. Soneson, J. M. Hayes.

SHORE, SIDNEY, Assistant Professor of Civil Engineering, Princeton University, Princeton, N. J. J. C. Elgin, E. J. Johnson, Jr.

SMITH, STANLEY L., Assistant Professor of Mathematics, U. S. Coast Guard Academy, New London, Conn. R. J. Perry, E. P. Rivard.

STARTZ, ARTHUR, Instructor in the Humanities (Economics), The Cooper Union, New York, N. Y. H. F. Roemmele, W. S. Watson.

STOLL, CHARLES B., Associate Editor, John Wiley & Sons, Inc., 440 Fourth Ave., New York, N. Y. W. B. Wiley, W. G. Stone.

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WAGNER, GLENN B., General Technical Services, General Electric Company, Schenectady, N. Y. M. M. Boring, C. F. Lee.

WALSH, GERALD W., JR., Instructor in Engineering Drawing, Syracuse University, Syracuse, N. Y. D. U. Greenwald, B. H. Norem.

WERNER, JULIUS M., Instructor in Mechanical Engineering, Syracuse University, Syracuse, N. Y. D. U. Greenwald, B. H. Norem.

WILLIAMS, EUGENE R., Instructor in Engineering, Bradford Durfee Technical Institute, Fall River, Mass. G. H. MacCullough, A. J. Ferretti.

WINN, WILLIAM C., Instructor in Electrical Engineering, Milwaukee School of Engineering, Milwaukee, Wis. H. D. Werwath, S. A. Eng.

ZABORSZKY, JOHN, Professor of Electrical Engineering, Missouri School of Mines, Rolla, Mo. J. W. Rittenhouse, I. H. Lovett.

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UPPER NEW YORK: B. H. Norem, *Vice Chairman;* A. D. Taylor, *Secretary.*

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*Chairmen listed on Section Meetings Page, Council Representatives listed on Officer's Page.

Minutes of Executive Board Meeting

A meeting of the Executive Board of the American Society for Engineering Education was held on Thursday, September 4, 1952, at the Drake Hotel, Chicago, Illinois. Those present were: W. R. Woolrich, *President;* M. M. Boring, J. H. Lampe, E. A. Walker, W. C. White, *Vice Presidents;* C. L. Skelley, *Treasurer;* A. B. Bronwell, *Secretary;* C. E. Watson, *Assistant Secretary;* M. C. Merrill, *Office Secrtary.*

Report of Secretary

a) *Committee appointments*

A list of new committee members was presented. Nominees for committee appointments had previously been obtained from Committee Chairmen. Members of the Executive Board were asked to review the list and submit recommendations for additions.

b) *Membership activities*

The membership drive this year will be organized largely by Institutions with a chairman in each engineering college. Emphasis will be placed upon expanding the membership among the younger faculty members in engineering colleges. The Division of Relations with Industry will be approached to suggest prospective members from industry.

c) *Advertising in Journal*

The Assistant Secretary has started a promotional campaign to increase advertising in the JOURNAL OF ENGINEERING EDUCATION, in order to obtain additional revenue for Society operations. Several hundred letters have been mailed to prospective advertisers and key individuals in various companies are being contacted.

A discussion of the advertising rates indicated that they are low in comparison with similar journals. It seemed inadvisable to increase advertising rates at this time, because the present rates have been announced in the promotional letters. The Executive Board voted to increase the JOURNAL advertising rates as of January 1, 1954, the new rates to be recommended to the Board by a commitee consisting of C. L. Skelly (Chairman), M. M. Boring, and C. E. Watson.

Report of Treasurer

Annual Audit

Treasurer Skelley reported to the Executive Board on the Annual Audit and specifically the Comparative Statement of Income and Expense for the twelve months ending June 30, 1951, and the twelve months ending June 30, 1952. The Executive Board also reviewed the budget for 1952–53.

Air Force ROTC Program

Dean Lampe reported on the special executive committee meeting of the ECAC on September 4th with officers of the Air Force ROTC program, including General Deichelmann, who is in charge of this program. The Air Force ROTC curriculum will be altered by the introduction of a general curriculum for all college students. This curriculum will not contain specialties, such as those given in previous Air Force ROTC programs. He stated that considerable attention was given at this meeting to the problem of the proper assignment by the ROTC of graduates who have received their training in engineering.

Recommendations of Coordinating Committee on Relations With the Federal Government

The Executive Board discussed the recommendation of the Coordinating Committee on Relations With the Government

to the effect that increased attention be given to the adequate placement of engineering graduates who are completing their military service. Vice President Boring stated that in many detachment centers, no organized procedure has been developed for the placement of such graduates and many of them are either accepting sub-professional work or are returning to military service or non-technical jobs because of inability to get adequate placement. Mr. Boring pointed out that the interviewing procedures set up at most of the detachment centers are entirely inadequate and sometimes unethical. He stated that the company representatives in their interviewing are compelled to use seriously crowded quarters and to abide by an interviewing schedule which is hopeless from the standpoint of getting effective results.

It was recommended that engineering deans call attention of the graduating seniors to both the placement service in the college and the Engineering Societies Placement Service, and urge those who go into the military services to contact these placement services before military detachment. President Woolrich will call this to the attention of the Society by means of a Presidential News Letter.

Future Annual Meetings

Secretary Bronwell stated that Cornell University had formally withdrawn its invitation to the Society for the 1955 Annual Meeting, in order to make it possible to hold this meeting at Pennsylvania State College, since this would coincide with the Centennial year at Pennsylvania State. The Executive Board voted to hold the 1955 Annual Meeting at Pennsylvania State College.

Plans for Annual Meeting at the University of Florida

It was recommended that there be three general sessions on Tuesday, Wednesday and Thursday mornings, as in the past, with one of these a general session of the Society and the other two sponsored by ECRC and ECAC. It was recommended that the general sessions start at 9:30 A.M., rather than 9:00 A.M. and that the program should be of more limited duration than last year. Secretary Bronwell stated that a new committee consisting of Drs. J. R. Killian, H. T. Heald, and A. S. Adams had been appointed to make recommendations for program material for the A.S.E.E. general session and banquet.

There was a discussion as to whether or not attempt should be made to implement the recommendations of the Barlow Committee Report in the Annual Meeting for 1953. It was decided to await recommendations of the Committee on Society Functions before proceeding in this matter. President Woolrich suggested that the University of Florida consider plans for commemorating the 60th Anniversary of the A.S.E.E.

The Executive Board expressed the opinion that most Divisions and Committees have a tendency to schedule too many conferences, resulting in numerous conflicts. Also, it was pointed out that several Divisions have tried a workshop type of program in which all participants discuss a planned program, but in which there are no scheduled speakers. These workshop programs have proven highly successful, since they increase the audience participation and often bring forth a more interesting treatment of the subject material than those containing prepared papers. It was suggested that the Divisions consider allotting more time for discussions of this character on some of their important problems.

Improvement of Journal of Engineering Education

Assistant Secretary Watson reported on the status of the JOURNEL OF ENGINEERING EDUCATION and presented suggestions which were being considered for improvement. It has been suggested that a few more articles of broad general interest to the Society membership at large, perhaps not dealing specifically with engineering education, but with subjects which are of vital interest to engineering

educators would improve the interest value of the JOURNAL.

Institutional Membership

Upon application from Bradley University, the Executive Board voted to change the status of this University from Affiliate member to Active member.

Secretary Brownell stated that Mr. McKeon is developing material for publicizing the Associate Institutional Membership possibilities among industries of the country.

Other Items of Business

In addition to the foregoing items, the Executive Board considered the following items, the recommendations of which are summarized in the General Council Minutes of September 4, 1952.

a. Reports of Vice Presidents;
b. Committee on Recognition and Incentives for Good Teaching;
c. Committee on Promotion of Ethics in Engineering Colleges;
d. Teaching position advertisements in the Journal;
e. Paper contest for young engineering teachers.

Respectfully submitted,
ARTHUR B. BRONWELL,
Secretary

Reserve this date . . . .

June 22-26, 1953

ANNUAL MEETING

UNIVERSITY OF FLORIDA
GAINESVILLE, FLORIDA

Minutes of General Council Meeting

A meeting of the General Council of the American Society for Engineering Education was held Thursday, September 4, 1952, at the Drake Hotel, Chicago, Illinois. Those present were: W. R. Woolrich, *President;* M. M. Boring, J. H. Lampe, E. A. Walker, W. C. White, *Vice Presidents;* C. L. Skelley, *Treasurer;* A. B. Bronwell, *Secretary;* C. E. Watson, *Assistant Secretary;* M. Merrill, *Office Secretary;* W. Allan, H. H. Armsby, R. M. Boarts, C. A. Brown, F. M. Dawson, K. B. McEachron, Jr., W. L. Everitt, C. J. Freund, W. P. Godfrey, L. E. Grinter, C. O. Harris, H. E. Hartig (substituting for T. H. Morgan), D. C. Hunt, E. Hutchisson, H. Keunzel, E. F. Obert, R. S. Paffenbarger, Thorndike Saville, E. Weber, K. F. Wendt, K. O. Werwath, C. L. Wilson, S. E. Winston.

Report of Secretary

The Secretary presented lists of new committee appointments and requested that additional suggestions from members of the Council be sent to either President Woolrich or the Secretary.

Professor Watson, the Assistant Secretary, briefly reviewed the advertising situation and stated that although the advertising rates in the Journal are considerable lower than similar publications, the Executive Board had decided not to raise the rates until January, 1954, since a campaign has been started to increase the volume of advertising in the JOURNAL.

Report of Treasurer

The Treasurer presented the final Audit for 1951–52 and discussed the Comparative Statement of Income and Expense. The Audit showed an excess of income over expense of $4,268.48 after having transferred $6,004.69 to the ECRC reserve. The latter transfer was voted by the Executive Board in June in order to establish a reserve fund which would even out the fluctuations in expense of the ECRC from year to year, owing to its cyclic publication schedule. The Secretary explained the 1952–53 budget. The income anticipates increases in revenue from increased membership, expansion of advertising in the JOURNAL, and expansion of the Associate Institutional Memberships in the Society. The budgeted expense makes provision for more time on the part of the Secretary and Assistant Secretary for A.S.E.E. business and also provides for salary increases of the office staff which were voted by the Executive Board on June 23. The expansion of Secretarial staff time will facilitate carrying on a campaign for increased advertising in the JOURNAL and provide for a general expansion of Society activities and better coordination of activities with other societies.

Report of Vice Presidents

Dean Walker reported on the ECRC activities, stating that a new secretary, Professor Virgil Neilly, of Pennsylvania State College, had been engaged. He commended highly the work of the previous secretary, John Mattill. The ECRC Committees have been appointed and the planning for the year's activities is now under way. The ECRC aranged for a program "The Engineer is a Scientist" for the Centennial Symposium in Chicago. The Committee on Contractural Relations With the Government is preparing a handbook dealing with relations with Government agencies in contractural research relationships. The ECRC also contemplates publication of a Review of Current Research during the coming year.

Vice President Boring announced the rules of the paper contest for young en-

gineering teachers. He will write Section officers, outlining the plan and urging them to give this matter widespread publicity.

Dean White stated that he is writing to chairmen of Divisions and Committees, recommending that they get started immediately in planning their Annual Meeting programs and also suggesting certain considerations, such as fewer conferences, more discussion time at the conferences, and better planned programs. He will also bring to their attention the need for advanced planning on any ASEE sponsored summer schools which the Divisions might propose.

Vice President Lampe reported that the Engineering Manpower Committee of the Society is under the chairmanship of Donald Bridgman, who will also be a member of the Engineering Manpower Commission. It was hoped that this arrangement would provide a closer liaison in manpower problems than has existed in the past. He also reported that the ASEE's program of Cooperation Between Engineering Colleges and Secondary Schools, which was started last year, is under the chairmanship of Dean Pierce of the University of Illinois. The Committee on International Relations will be headed by Dean Steinberg and the Committee on Selection and Guidance by Dean N. W. Dougherty.

Committee on Recognition and Incentives for Good Teaching

President Woolrich stated that the Committee on Improvement of Teaching of the ASEE had just completed a highly commendable report on this subject, copies of which would be made available at cost in any quantity desired to engineering colleges for distribution among their faculty members. However, he stated that there is another phase of this problem which was not within the scope of the committee's study, but which is highly important from the standpoint of improving the quality of education in engineering colleges. There is a growing trend among teachers in engineering colleges to place great emphasis upon research accomplishments, consulting, and contributions to technical literature. While these objectives are highly commendable, they often result in a general deterioration in the quality of teaching, since a number of teachers are inclined to devote a disproportionately large amount of their time to these secondary activities. He recommended that consideration be given by the ASEE to the appointment of a committee to study means of providing recognition and incentives for commendable teaching, in order to encourage faculty members to give greater consideration to this primary function. In the discussion of this problem it was pointed out that the situation is one which is generally recognized by faculty members and administrators alike, but no serious attempt has been made to evaluate the problem or to recommend administrative practices for alleviating the difficulty. The Executive Board voted to authorize appointment of such a committee, to report to the General Council of the Society.

Committee on Promotion of Ethics in Engineering Colleges

The decline of ethical standards in engineering practice is a subject of great importance which has been called to the attention of educators and the Society on innumerable occasions. The teaching of ethical precepts of the engineering profession is given very little attention in most engineering colleges. A number of professional engineers have expressed the opinion that engineering colleges are lax in their recognition of responsibility in this regard. It was suggested that the teaching of ethics should be woven into all of the engineering courses, rather than set aside as separate instruction. The General Council recommended that a committee on Promotion of Ethics in Engineering Colleges be appointed, with the request that it prepare a report recommending various types of programs which the colleges could consider.

Paper Contest for Younger Faculty Members

A suggested set of rules for conduct of the paper contest for young engineering faculty members was considered by the Executive Board and General Council and adopted. The purpose of the paper contest is to stimulate original thinking on the part of younger faculty members in engineering colleges and encourage their active participation in Society problems. Previously, the General Council had voted to authorize two prizes of $200 and $100 for the two prize winning papers. Each Section of the ASEE would announce the competition among the younger faculty members within its jurisdiction in order to encourage participation and would establish a procedure for judging the papers and submitting the winning entries to ASEE Headquarters. The awards will be presented at the Annual Banquet, along with the Lamme Award and the George Westinghouse Award. The rules for the paper contest are as follows:

a. Open to all members of ASEE under 36 years of age.
b. Subject of paper contest will be announced by the President of the ASEE.
c. Papers should not exceed 3,000 words in length.
d. All entrees should be submitted to the officers of the ASEE Section in which the participant resides.
e. Each Section of the ASEE will appoint its own judging committee, formulate its own rules, and select one winning paper for submission to ASEE Headquarters.
f. A national judging committee will select the winning papers.
g. The awards will be $200 for first place and $100 for second place, with appropriate certificates.

Conference of ECAC on ROTC Plans

Dean Allan, reporting for the Military Affairs Committee of the ECAC, stated that considerable attention had been given by his committee to the problem of the disposition of ROTC graduates by the Army and Air Force after graduation. According to present practice, a graduate whose primary field of classification is filled is permitted to accept civilian employment until his primary field is open. There is considerable question among engineering educators as to whether this desirable condition will prevail of the ROTC programs are altered and the technical training courses are replaced by general courses. The following resolution was presented by Deans Saville, Grinter and Lampe:

"That the Council of ASEE believes that the acceptance of the proposed general programs of Army-ROTC and of Air Force-ROTC with the abandonment of the long-established professional branches such as Signal Corps, Engineering Corps, Ordnance, Chemical Warfare and corresponding specialties in the Air Force will reduce the number of engineering trained Cadet Officers so badly needed by the military services and will also increase the deficit of engineers required for the industrial effort associated with national defense production due to the diversion of engineering ROTC graduates to military services where their engineering capabilities are not fully utilized.

"The Council of ASEE therefore recommends to the administrators of institutions teaching engineering that acceptance of any changes involving possible abandonment of the existing professional Army-ROTC and Air Force-ROTC branches be deferred pending immediate conferences of the officers of the Society with the proper representatives of the Military Services and subsequent report to the Institutions involved."

The Counicl approved this resolution with the request that it be sent to Presidents of Colleges, with copies to the Engineering Deans and also to the proper officials in charge of Army and Air Force ROTC programs.

Teaching Position Advertisements in Journal of Engineering Education

A questionnaire sent to members of the General Council and deans of engineering colleges inquired as to their recommendations regarding the possibility of including in the JOURNAL OF ENGINEERING EDUCATION advertisements of teaching positions. This yielded the following results: 71 persons favored inclusion of such advertisements, 11 opposed; 60 persons favored including advertisements of individuals seeking positions, and 44 opposed; 25 persons favored including salaries, 52 opposed. It was pointed out that listing teaching positions in the Journal might bring into the teaching profession some capable persons from industry, thus reversing the flow of teachers into industry which is now taking place.

The General Council voted that advertisements of teaching positions be included in the JOURNAL for a trial period of one year; that no advertisements of individuals seeking positions be included; that no salaries be included in such advertisements; and that this opportunity be extended only to schools which are either Active or Affiliate Institutional members of the A.S.E.E.

Plans for Annual Meeting at the University of Florida

The Executive Board recommendation that the general sessions of the Society be devoted to subjects of widespread, vital interest to the Society membership and include nationality ETAOINETA and include nationally prominent speakers was presented. It was suggested that committee reports might be referred to other portions of the Annual Meeting program.

The possibility of devoting a General Session of the Society to a discussion of Society business and a presentation of reports on important developments was discussed. No action was taken, although it was recognized that such a general session, if included, should be carefully planned in advance.

Free Distribution of Journals to Foreign Countries

A suggestion that copies of the JOURNAL OF ENGINEERING EDUCATION be sent to libraries of European countries in order to gain more widespread recognition of the Society in foreign countries was discussed. It was suggested that 17 copies be sent to Great Britain, 1 to Holland, 1 each to the Scandinavian countries, and 8 or 10 copies to France. It was also suggested that a letter explaining the distribution be sent to each recipient institution.

The General Council voted to distribute 50 free copies monthly for a trial period of one year to foreign countries.

A.S.E.E. Emblem

Dean Freund presented three designs for the A.S.E.E. emblem, suggested by Profesor Blakesly of the University of Detroit's Architectural Department. These were slight modifications of a previous design tentatively adopted by the Council. The Council voted to adopt one of the designs submitted.

Life Membership

The General Council voted to grant the following persons life membership in the Society:

1. G. M. Butler
2. T. E. Butterfield
3. W. L. DeBaufre
4. E. P. Lambe
5. W. H. Martin
6. H. H. Metzenheim
7. C. J. Starr
8. J. S. Thompson
9. C. W. Tudbury

Respectfully submitted,
ARTHUR B. BRONWELL,
Secretary

Report of Committee on Salaries, Southeastern Section*

Preface

This project is the result of feeling on the part of some of the members of the Southeastern Section that a current survey of salary information in engineering schools is desirable and necessary at this time. The last available and reliable information with regard to teachers' salaries in engineering schools for this region is to be found in the report of the Committee on Faculty Salaries of the Engineering College Administrative Council of the American Society for Engineering Education which was released in June 1949 and covered in general the academic year of 1948 through 1949. Without question, a great deal has happened which has had a tremendous impact upon engineering education since that date. The committee hopes that the facts and indications found herein will be of value to the administrations. It also hopes that the trends found in this study will be useful to stimulate a development which is long overdue in the engineering profession. The engineer who feels an obligation to his profession and assists in the training of future engineers has been forced for much too long a time to sacrifice the comfort and sometimes even the health of himself and his family in order to accomplish his purpose.

The committee is convinced that there is little incentive today capable of attracting excellent young men to the teaching profession if they aspire to the responsibilities of the upper academic ranks. The committee also feels that there is solid evidence in the report of a very dangerous trend which the popular writers might call "creeping socialism."

The most socialistic aspect of the general situation is the tendency to diminish continually the range of compensation between the lower and the higher grades in the teaching profession. In some instances, it has already resulted in competent, forceful, and ambitious young engineering teachers leaving the profession because they cannot conceive of their continuance therein holding any real promise. The decentive characteristic of all but a few of the rate structures surveyed in this report is almost appalling. The committee calls attention to this problem with real and sincere hope that the trend can be and will be reversed. It feels that it is second only in seriousness to the general situation of the appalling low, non-competitive rate structures available to attract competent, sincere and forceful young men into engineering teaching. Recently an ex-governor and prominent president of one of our southern universities made a very astute observation when he said that if the situation with regard to faculty salaries continues much longer, only the aged, the incompetent and the loyal will remain to teach the coming generations. Such a condition can lead only to a decline in the standards and excellence of the engineering staffs, which in turn will inevitably lead to a decline in the standards and excellence of engineering instruction, and thus in a short time to a decline in the competence and ethics of the engineering graduates and the professional engineers of the future. This our nation cannot afford nor endure.

Introduction

The committee sent out survey forms to accumulate data with regard to the salary ranges, the number of staff members, sum-

*Southeastern Section, Reported at the Clemson Meeting, April 12, 1952.

mer session salaries, and gains and losses of staff members for the academic years 1950–51 and 1951–52 to all twenty-four of the engineering schools in the southeastern region. The twenty-one schools which responded are listed below:

Alabama Polytechnic Institute
University of Alabama
University of Florida
University of Kentucky
Louisiana Polytechnic Institute
Southwestern Louisiana Institute
Louisiana State University
University of Mississippi
Duke University
North Carolina State College
University of Louisville
Clemson College
The Citadel
Tennessee Polytechnic Institute
University of South Carolina
University of Tennessee
Vanderbilt University
Virginia Military Institute
Virginia Polytechnic Institute
University of Virginia
University of Miami

Since the committee felt that this survey had three analytical objectives; i.e., the analysis of rate structures, the analysis of summer school salaries, and the analysis of quits and layoffs; the data as received was accumulated into tables to reflect these facts. These tables were set up to show a comparison between data pertaining to the academic year 1950–51 and the academic year 1951–52. Because of some of the inherent deficiences in the data, it was impossible to set up the data in the same manner as the 1949 ASEE report on teachers' salaries. The 1949 report was able to report medians because individual data with regard to salaries and other forms of compensation was obtainable. Neither time nor funds were available to obtain such detailed data for this current regional survey. The committee felt that the presentation of weighted averages and simple arithmetic averages, though leading to some error, would be sufficiently useful for comparisons.

Rate Structure

A condensation of the detailed data received in this survey is presented in Tables A and B and Charts A and B. An attempt was made to indicate the relative pay status by the usual grades.

TABLE A

RATE STRUCTURE—ACADEMIC YEAR (10 MONTHS)

Grade	Year	Minimums of Ranges			Average Salary Paid	Maximums of Ranges		
		Min.	Ave.	Max.		Min.	Ave.	Max.
		$	$	$	$	$	$	$
Instructor	1950–51	2300	2720	3120	3151	3020	3441	4000
	1951–52	2500	3077	3500	3427	3120	3336	4180
Asst. Prof.	1950–51	2960	3367	4000	3784	3040	4014	4800
	1951–52	3289	3693	4200	4094	3600	4290	5000
Assoc. Prof.	1950–51	3280	4023	4800	4573	3680	4801	6000
	1951–52	3440	4281	5000	4749	3760	5062	6000
Professor	1950–51	3920	4914	6000	5647	4320	5606	7500
	1951–52	4264	5212	6000	5980	4784	6180	8348
Dept. Head[1]	1950–51	3800	5176	6960	5670	4270	6047	7500
	1951–52	4770	5547	7332	5715	5050	6346	7932

TABLE B

RATE STRUCTURE—12 MONTHS PAY BASIS

Grade	Year	Minimums of Ranges			Average Salary Paid	Maximums of Ranges		
		Min.	Ave.	Max.		Min.	Ave.	Max.
		$	$	$	$	$	$	$
Instructor	1950–51	3000	3317	3800	3739	3688	4028	4500
	1951–52	3444	3746	3888	4148	4104	4432	5300
Asst. Prof.	1950–51	3700	3969	4320	4614	3800	4852	5700
	1951–52	3850	4271	4900	5055	4500	5043	5600
Assoc. Prof.	1950–51	4100	4414	4800	5354	4600	5517	6600
	1951–52	4300	4599	4800	5655	4700	5601	6800
Professor	1950–51	4900	5552	5916	6183	5400	6821	8100
	1951–52	5200	5862	6300	6592	5600	6938	9000
Dept. Head[1]	1950–51	4600	5829	8000	6839	5400	7397	9500
	1051–52	4700	6301	8372	6991	5600	7663	9872
Dean[2]	1950–51	6677	7238	7536	7801	5800	7927	11,500
	1951–52	7039	7270	7500	8266	6000	8393	11,896

[1] Include some at associate professor rank, but most at professor rank.

[2] Range data (minimums and maximums) not fully reported, therefore may not be significant. Average salary paid based upon complete data.

The 1949 ASEE survey presented all of the data on an academic year payment basis. This common denominator was not selected for the current survey. It was the feeling of the committee that there is significance in the number of schools which employ and pay their staff on a 12 months basis. For this reason this data was accumulated and is presented in detail without change in the basis of payment.

An attempt was made in Tables A and B to analyze the rate range by grade and average salaries by grade. An attempt was also made to compare the minima and maxima to a scale recommended by the National Society of Professional Engineers and the American Society of Civil Engineers in 1946–47 for the payment of engineering teachers' salaries. This information is presented graphically in Charts A and B.

Charts A and B provide a shameful comparison to attainment of a recommendation made five years ago. They also reveal the extremely unfortunate decentive situation which exists in the rate structure of the colleges of this region. With so little to look forward to, it is difficult to understand why or how the administrations of the colleges herein represented can expect to obtain the type of young engineer that the profession demands for its engineering staff members. Without comparison to the salaries obtainable in industrial situations, but merely by the analysis of what the future holds in terms of engineering education, these charts present little in the way of an incentive. More important, they reveal what must be a firm belief in the minds of the administrative personnel who are responsible for the establishment of rate structure that experience means little in engineering education. If this were not so, why else would the relationship between the lower ranks and the higher ranks be so close and offer so little incentive for the assumption of the obligations which are inherent in the

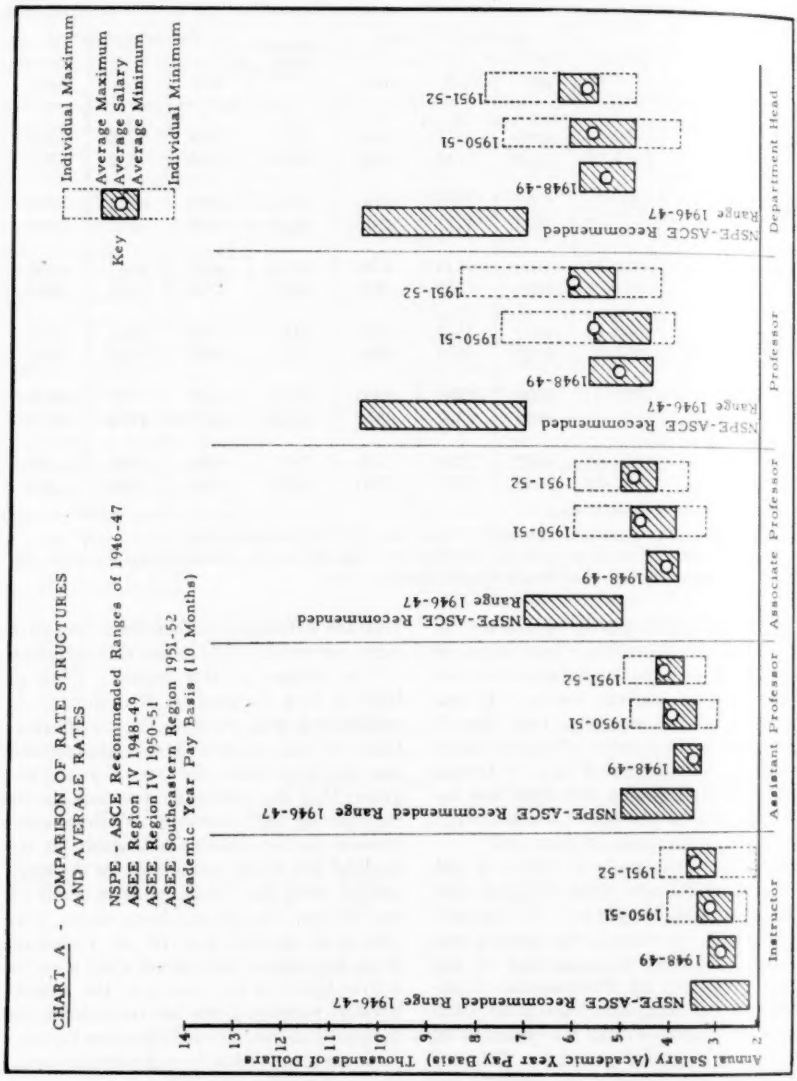
CHART A - COMPARISON OF RATE STRUCTURES AND AVERAGE RATES
NSPE - ASCE Recommended Ranges of 1946-47
ASEE Region IV 1948-49
ASEE Region IV 1950-51
ASEE Southeastern Region 1951-52
Academic Year Pay Basis (10 Months)
Key
Individual Maximum
Average Maximum
Average Salary
Average Minimum
Individual Minimum
Annual Salary (Academic Year Pay Basis) Thousands of Dollars
14
13
12
11
10
9
8
7
6
5
4
3
2
NSPE-ASCE Recommended Range 1946-47
1948-49
1950-51
1951-52
Instructor
Assistant Professor
Associate Professor
Professor
Department Head

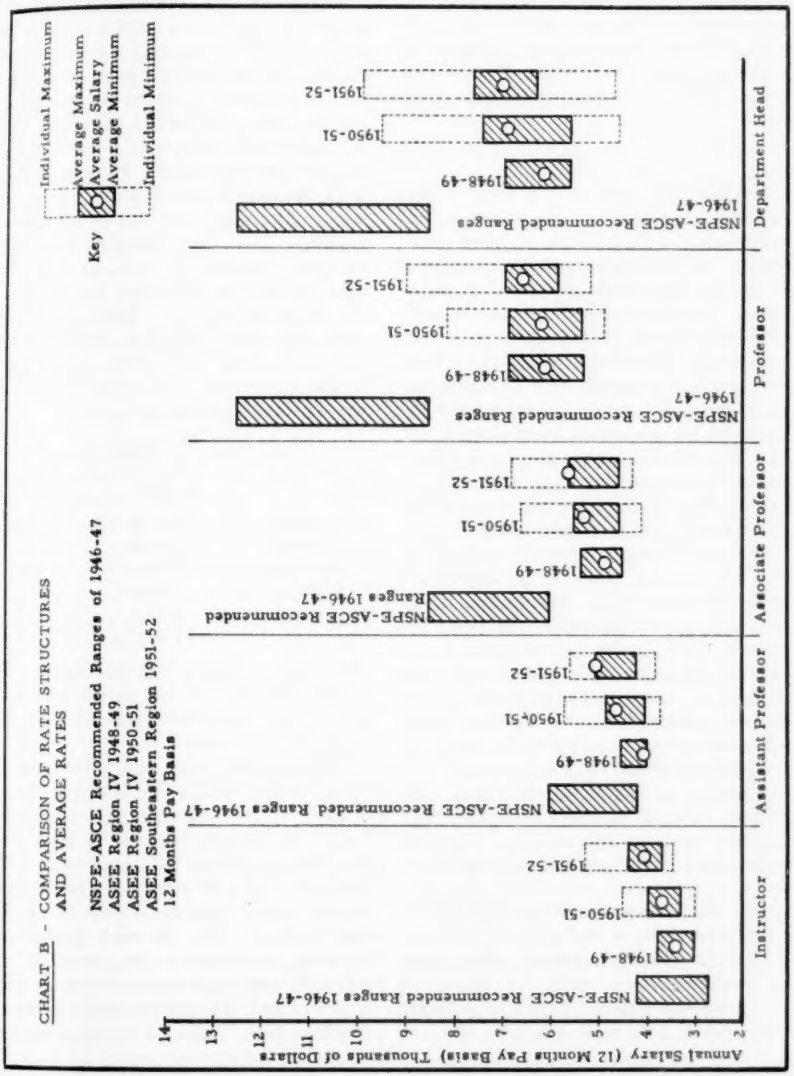
CHART B - COMPARISON OF RATE STRUCTURES AND AVERAGE RATES
NSPE-ASCE Recommended Ranges of 1946-47
ASEE Region IV 1948-49
ASEE Region IV 1950-51
ASEE Southeastern Region 1951-52
12 Months Pay Basis
Key
Individual Maximum
Average Maximum
Average Salary
Average Minimum
Individual Minimum
Annual Salary (12 Months Pay Basis) Thousands of Dollars
14
13
12
11
10
9
8
7
6
5
4
3
2
Instructor
Assistant Professor
Associate Professor
Professor
Department Head
NSPE-ASCE Recommended Ranges 1946-47
1948-49
1950-51
1951-52

higher ranks? These charts and tables also reveal a very definite tendency, which the committee feels to be a dangerous one, to increase the rate structures in the lower scale without corresponding increases in the upper parts of the scale. This is ruining an already tragically poor rate structure.

Summer Sessions

Generally the engineering teacher must support his family on his academic year salary for a full fifty-two week year. Only a small percentage of those employed in teaching are able to increase their net income. Summer school teaching is not available for all, nor is the time during the summer session of sufficient duration to make for profitable employment in industrial situations. In many instances, summer positions require living away from home, and this added expense greatly decreases the net gain resulting from such employment. The older, more experienced faculty member with industrial contacts, prestige and standing is sometimes able to increase his annual income to an appreciable extent through consulting or other industrial employment during the summer. The men of lesser experience, however, do not have this opportunity. In addition to this, it must be recognized that seniority and rank in general have an important effect upon determination of who is employed for teaching in the summer sessions.

Analysis of the data was made with reference to pay during the regular term and for the summer session. The data showed wide variations and indicated that:

(a) The length of summer term varied from 6 to 12 weeks

(b) The weekly summer school pay varied from 60% to 115% of weekly academic year pay based upon a 36 week schedule.

In order to obtain the weekly pay for those on a 12 month basis, the average salary was divided by 46. The committee recognizes that there is no magic in the number 46; however, it is admitted and seems to be the most common practice that about six weeks of vacation are allowed to those members of the staff who are employed for the full 12 months basis. While a 46 week base year may seem to embody within it an exceedingly long vacation period or an excessive amount of free time in comparison to industrial situations, some thought should be given to this before such comparisons are made. The usual industrial concern allows a minimum of two weeks of vacation per year for all salaried employees and it is becoming even more common practice to allow an additional week or two for more than ten to twenty-five years of service. Furthermore, the usual industrial practice requires a five day work week and allows six to eight holidays per year. A comparison of free time is tabulated below:

COMPARISON OF "FREE TIME"

	Industry	College (12 mo. pay basis
Vacation	14 days	42 days
Saturdays	50 days	23 days
Sundays	50 days	46 days
Holidays	7 days	3 days
	121 days	114 days

This table indicates that engineers in industry have about one week's more free time. The committee believes that this analysis is a realistic one.

The academic year salary was reduced to a weekly salary by dividing by 36 weeks. It is recognized that a 36 week year is not exactly realistic, as those serving on an academic year basis do have additional weeks of required work and do put in more time than this during the school year. The 36 week period was adopted, however, as representing two usual 18 week semesters or three 12 week quarters and thus representing the actual teaching time. This made it possible then to divide the summer salary by the number of the weeks of summer session and arrive at a comparable salary figure. It is recognized that the summer session will require some additional time above and beyond the actual weeks of teaching called

for during the period, so that the comparison is not too unrealistic when compared to the full forty-six week year, or the academic year of 36 weeks.

Although considerable discussion has already been presented with regard to the treatment of this data, it is believed that some comment is necessary with regard to the extreme lack of uniformity of payment. It seems that college administrators in reviewing this material might do well to give some thought to some uniformity of payment to their staffs for their services. Attention is called to the numerous instances wherein the difference in payment for the service during the academic year varies to a great extent, both higher and lower, from the payment for the summer session.

Analysis of Distribution by Academic Rank

The committee felt that it would be interesting to analyze changes in the distribution of staff members within the region by academic rank for the two years under survey, and to make a comparison with the distribution of staff members found in the ASEE report of 1948–49. Because there was no significance in the distribution of deans, this data was omitted. This analysis is presented in Chart C, Distribution of Staff by Academic Rank. A careful analysis reveals two apparent tendencies. (1) Because of declining enrollment, there was a decrease in staff from 1950–51 to 1951–52. It is apparent that most of the change or reduction took place in the two lowest ranks. (2) It is also apparent by inspection that there was an increase in promotions to the higher ranks, particularly to the associate professorship rank over the two year period. It is thought that these two occurrences may bear some relation to a single cause.

The abnormal demand for engineers and engineering brainpower definitely led to a movement on the part of many of the younger staff members to go into industrial practice and receive an income which would allow them to supply their families with more of the needs and perhaps even a few of the luxuries of our civilization for which they were making contributions through their professional skill. It is believed with some reason that many of the schools resisted the loss of these men by promotions at a time in advance of that which would normally be expected. This has resulted in an increase in the number of associate professors in the 1951–52 year over the 1950–51 year, even though there was a reduction of 181 staff members in the region.

An interesting comparison can be drawn to the distribution in this region, both in 1948–49 and in the past two years, to the overall distribution by rank throughout the entire coverage of the 1949 survey. The southeastern region, even in 1948 and 1949, showed a tremendously heavier concentration of staff members in the lower ranks than in the nation as a whole. The recent reduction in the lower ranks tends to put this region more nearly in line with what would appear to be the usual distribution of staff by rank throughout the country.

Staff Turnover

An analysis was made of quits and layoffs in the various schools in the region which submitted data. As this data was accumulated, deans and assistant instructors were excluded from the analysis because of lack of significance in the data available. This data was accumulated by colleges, and reveals that there was an important increase in quits from the year 1950–51 to 1951–52. The quit rate increased from 8.0 to 13.0. Some schools had no separations whereas others suffered a 29.3% loss. Some correlation between the wage scale of the colleges and their quit ratio was evident. The eighty quits over the two year period averaged $1,696.70 estimated increase per year. This covers all ranks and quits to change to industry and other teaching positions. The minimum reported increase was $600.00. The maximum reported increase was $5600.00. The data was not heavy enough to analyze by year, or by rank, or by rea-

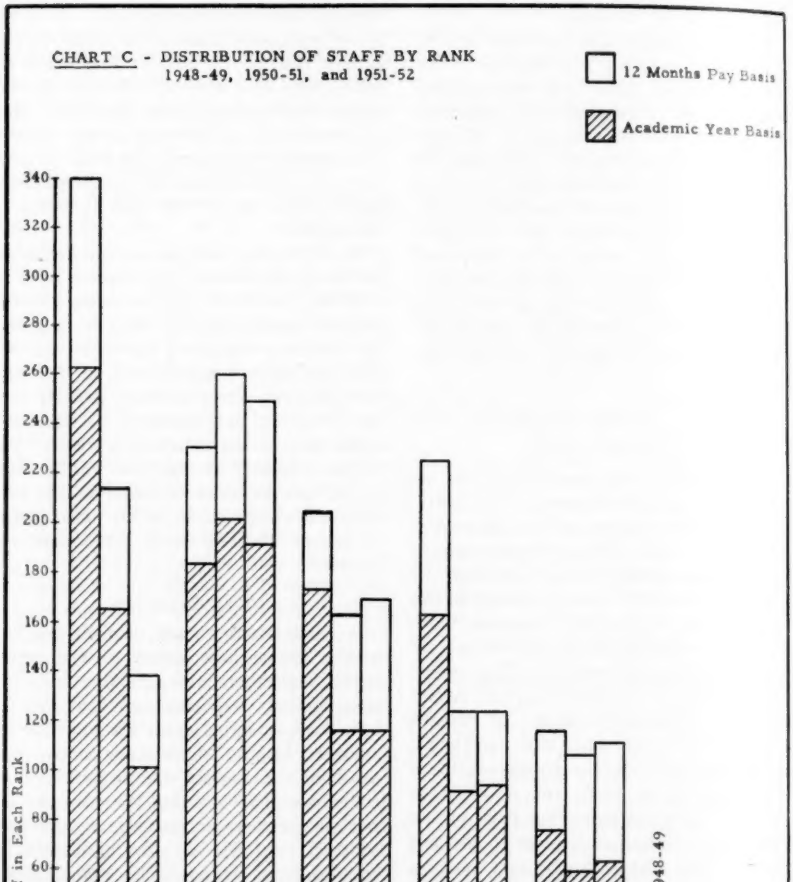
CHART C - DISTRIBUTION OF STAFF BY RANK
1948-49, 1950-51, and 1951-52
12 Months Pay Basis
Academic Year Basis
Number of Staff in Each Rank
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
1948-49
1950-51
1951-52
Instructors
Assistant Professors
Associate Professors
Professors
Department Heads
No data 1948-49
Deans

son for quit. Most reasons given for quits were financial.

An attempt was made in this survey to find out why the quits were occurring and if the primary cause has been for more money, just how much or even approximately how much of an increase in salary was being received by the persons who left the academic atmosphere for industry, or changed the atmosphere to another institution. Unfortunately, many of the deans reporting this did not have sufficient data on hand to make an individual college by college analysis possible nor an analysis by ranks. The majority of the quits was caused by a desire for more money. Interestingly enough, the detailed returns revealed that when a staff member quit to go to another college, his increase in salary was approximately the same or at least within the range of the middle fifty per cent of the increases received in the transfer of college staff members to an industrial atmosphere. There was, furthermore, no significant difference in the amount of money received for leaving the academic field in the 1950–51 period as compared to the 1951–52 period. While the quits over the two year period averaged some $1700 per year increase, a comparison of salary opportunities and salary structures in other branches of the engineering profession will show how easy it is to obtain this increase in annual income by an engineer who desires to leave the academic atmosphere.

Comments and Comparisons

Two brief comparisons were attempted, one with salary opporunities in fields of engineering other than teaching, the other in comparison to another profession.

Comparison of Median Salaries of Engineering Teachers in Region IV with Average Net Income of Physicians

Mr. William Weinfeld of the United States Department of Commerce made an exhaustive survey of the income of physicians during 1929 to 1949. This was reported in the publication, Survey of Current Business, published under the auspices of the United States Department of Commerce. Information from this study is presented below in comparison to median salaries obtained from the ASEE survey of teachers' salaries previously noted which were adjusted for a 12 months base by adding twenty percent. Salaries were compared in terms of average age in order to obtain a comparison with the information in the U. S. Department of Commerce publication of physicians income. The median salary of instructors is tabulated with the average age of instructors as opposed to the income of the same aged group from the aforementioned publication. This data is presented in summary form below.

While it is admitted that the physician spent more time in education before starting his period of earning in the past, the recent growth of graduate work and emphasis on doctorate degrees and experience in the higher ranks of engineering faculty members is closing this breech. It is hard to conceive that the disparity in incomes revealed by this comparison is commensurate with either the responsibility or the required education of the two professions, and again it becomes most evident that the decentive characteristic

	Median Salary[1]	Average Age[2]	Average Net Income of Physicians[3]	
			Age Group	Net Income
Instructor	$3360	30	30–34	$ 9,806
Asst. Prof.	4080	36	35–39	12,608
Assoc. Prof.	4920	44	40–44	14,476
Professor	6120	49	45–49	14,967
Dept. Head	6360	55	55–59	13,226

[1] From ASEE Survey of Teachers' Salaries in Engineering Schools, Region IV, 1948–49, adjusted for 12 months base by adding 20 per cent.

[2] Estimated from data in ASEE survey of teachers' salaries in engineering schools, Region IV, 1948–49.

[3] Source—Table 16, page 22, "Income of physicians" by William Weinfeld, U. S. Department of Commerce.

of wage advancement in the engineering teaching field is an important and frightening problem at the moment and one to which attention must be paid.

Comparison of Engineering Teaching Salaries in the Southeastern Region with Salaries in Civil Engineering

The August 1951 issue of *Civil Engineering*, published by the American Society of Civil Engineers, contains its annual survey of salaries for the civil engineering profession. In this issue an analysis is made of salaries paid under different conditions to professional personnel performing civil engineering functions. An abstract of this data is presented in Table C which compares average salaries determined from this survey for the 1951–52 period for instructors, assistant professors, associate professors, professors and department heads combined, and deans with a corresponding pay grade in the civil engineering survey. Salaries are reported in the civil engineering survey for 40 consulting firms covering 1886 engineers, 19 construction firms covering 2194 engineers, 70 private organizations reporting 5526 engineers, 22 state highway departments reporting salaries of 14,927 engineers, 21 municipalities reporting salaries of 1935 engineers and 50 public organizations such as county, regional, and large federal authorities reporting the salaries of 18,045 engineers. A further comparison is made to the recommended ranges for engineering teaching profession which have been published by the American Society of Civil Engineers and have been endorsed by the National Society of Professional Engineers. The recommendations were made in 1946 and so for purposes of comparison were adjusted upward by 25% to reflect the approximate change in the cost of living since the time of the recommendation.

A study of Table C is almost frightening in terms of the probability of obtaining competent, young engineering personnel in the engineering teaching profession. It is apparent that if the young engineer is not concerned with "security" and is more concerned with "opportunity," he will point his future towards the possibility of entering the consulting field. If, on the other hand, he is looking for and is interested in "security," he will have more interest in state highway departments, municipalities, and the public organizations. The socialistic or leveling tendency in the rate structure is apparent as we move from the more competitive situations to the more restrictive situations which are controlled by or are paid through taxation or public moneys. It is apparent that the longer one works for the public, the lower such experience and professional development is valued.

Engineering Education Salaries vs. Engineering Industrial Salaries

Another simple comparison which can be made is the comparison between the beginning salary of the recent engineering graduate should he be hired by private industry or by the colleges.

Let it be said, and let it be recognized but not disputed, that the type of individual sought for engineering teaching is the same type of individual sought by the best private employers. The young man desired by the private employer is a graduate in the upper third of his class, articulate, reasonably mature, who has given evidence of leadership and the ability to command the respect of others. This same type of man is what the engineering teaching profession needs. Private employers are offering young men of this caliber an entering salary of $325 per month to $350 per month. This same young man, should he seek to enter the teaching profession, would be forced, as this survey reveals, to accept a starting salary not much in excess of $250 per month. Obviously, engineering colleges cannot hope to interest a sufficient number of young men, or the proper type, in engineering teaching if this condition is to exist. On the other hand, if the college administrations seek even to approximate a competitive salary scale with industry, they would have to pay what would approximate the entering sal-

TABLE C

Comparison of Rate Structure of Engineering Teaching Positions in Southeastern Region ASEE with Salaries of Civil Engineering Positions and Recommended Salary Ranges for Engineering Teaching Positions

Annual Salaries

ASCE Grade	Equivalent Rank	ASEE[1] 1951–52 Survey		ASCE 1951 Survey[2]												ASCE[3] Recommended Ranges for Engr. Teaching	
		Ave.	Ave.	Consulting Firm		Construction		Private Organization		State Highway Depts.		Municipalities		Public Organization			
		Min. $	Max. $	Min. $	Max. $	Min. $	Max. $	Min. $	Max. $	Min. $	Max. $	Min. $	Max. $	Min. $	Max. $	Min. $	Max. $
1–2	Instructor	3020	3636	3100	3900	3380	4050	3100	3921	2725	3330	3180	3860	3005	3655	3380	5250
3–4	Asst. Prof.	3693	4290	4600	5400	5000	6000	4690	5400	3980	4590	4288	4900	4250	4910	5250	7650
5–6	Assoc. Prof.	4281	5062	6340	7500	6820	7510	6370	7350	5540	6265	5100	6300	5590	6470	7650	10,750
7–8	Prof. and Dept. Heads	5212	6346	8800	10,500	8735	9800	8810	10,000	7200	7700	6730	7900	7200	7945	10,750	15,750
9	Dean	—	—	11,325	22,000	12,000	15,550	11,450	17,400	7735	9990	6680	12,800	7980	12,300	15,750	up

[1] Source—Average minimum and average maximum of schools reporting in Southeastern Region—1951–52 scales on a 10 months basis.

[2] Source—"Survey of Salaries for Civil Engineering Positions"—*Civil Engineering*, August, 1951—Tables III and IV. Minimum of range selected as entrance rate median of lower grade of ASCE grade; maximum of range selected as entrance rate median of higher ASCE grade for each level of teaching rank.

[3] Source—Report of ASCE recommending salary scales for engineering teachers—1946; adjusted upward 25% to reflect changes in cost of living since report.

ary for the associate professorship level, or would have to pay what an engineer of some 20 to 25 years of professional experience is getting if employed in the engineering teaching profession. The charts and tables already reviewed reveal the very severe decentive characteristics of the existing rate structure.

Obviously this characteristic of payment cannot continue, or it will not be possible to interest those capable young men now engaged in the teaching profession to continue in their chosen field.

Respectfully submitted,

PROF. FRANK F. GROSECLOSE
PROF. H. L. MANNING
PROF. LOUIS R. SHOBE
DR. W. P. WALLACE
DR. GORDON C. WILLIAMS
PROF. DAN H. PLETTA, *Chairman*

The following six papers were presented at the ASEE Centennial Symposium on Engineering Education and Training under the Chairmanship of A. A. Potter, Dean of Engineering, Purdue University, September 4, 1952.

History of Engineering Education by Frederic T. Mavis

Achievements to Date in Engineering Education by Thorndike Saville

The Technical Institute—Its Relation to Engineering Education and Trade Training by C. W. Beese

The Engineer and the Scientist by W. F. G. Swann

Looking Ahead in Engineering Education by S. C. Hollister

Looking Ahead in Engineering Education by L. M. K. Boelter

History of Engineering Education*

By FREDERIC T. MAVIS

Professor and Head, Civil Engineering Department, Carnegie Institute of Technology

Introduction

Dr. Harry P. Hammond, Dean Emeritus of Engineering at the Pennsylvania State College, was originally scheduled to speak to you on this subject—and no one is better qualified than he to brief the history of engineering education. When he became ill early in June, I was invited to pinch-hit for him and to adapt for this meeting a talk I had given in March to the West Virginia Section of the American Society of Civil Engineers and excerpted in *Carnegie Magazine* in June under the title, "Our Engineering Heritage." I am very happy to do this, realizing (as each of you does) that the history of engineering education can not be skimmed in thirty minutes, even with such able discussers to supplement or to correct what I may say. Moreover, the *history* of engineering education (which is my assignment) can only with difficulty be fenced off from the *achievements* in engineering education which is the topic assigned to Dean Saville who will speak to you later. Accordingly, I shall limit my remarks to *origins and growth* of engineering education and to the *heritage of ideas* that may help set up a reflective mood in this Centennial Symposium.

Engineering in its broadest terms is the art of directing the great sources of power in Nature for the use and convenience of man. It is an art as old as civilization itself, because men have always had to wrestle with the power of Nature.

Men must obey Nature's unwritten law. They may yield to it passively . . . or by their ingenuity and enterprise bend it to their own convenience and use. Nature does not change her course because men argue—however eloquently—that things should not be as they are; nor is she impressed by strong muscles and bluster. Yet all around us there is evidence that fierce Nature can be transformed into a useful servant or a household pet by those who will *learn* her ways, and *plan ingenious means* to work in harmony with her. The story of man's *learning* and planning to adapt power in nature to his use and convenience is primary; the story of his *teaching* is secondary. Learning and teaching go together, and a few diligent students will soon reflect the strength of their teachers . . . but what can a teacher do among "students" who will not learn?

If engineering arts are as old as civilization, engineering education can not lag far behind. I shall fall back on legend and history to support what I have to say.

The Mosaic Legend

Probably no other legend is more deeply rooted in our mores than the legend of the creation and the fall of man—the legend of Adam and Eve, of Cain and Abel—and there has been much speculation about where Cain got his wife. The First Book of Moses is often tiresome with geneology and "begats," but it merits thoughtful reading for my

* Presented at ASEE Centennial Symposium on Engineering Education and Training, Chicago, Illinois, September 4, 1952.

present purpose of engineering and education.

When Cain was banished, he got his wife from the land of Nod and raised his family there. (What engineering teacher doesn't get his eight-o'clock classes from the same place and keep them there much of the time he is lecturing?) According to this legend, Cain built a city which he named after his first son Enoch. Today, the job of planning cities, of building them, of supplying them with water and with facilities to remove wastes, of providing ways that men and goods can be transported efficiently in and between cities, often of managing municipal enterprise itself . . . is the work of a civil engineer. Whether Cain was the first woman-born civilized man is not important; but the legend that he constructed the first engineering works of civilized man by building a city is interesting. The Mosaic legend is not in conflict with my first premise that, whatever it may have been called, civil engineering is coeval with civilization. And all other branches of engineering as we know them today—except *strict* military engineering—have grown from the main stem of civil engineering within the last hundred years.

If you follow the line of "begats" you will find the sixth lineal descendant of Adam in the *Cainite* line is Lamech, son of Methusael, who introduced polygamy by marrying Adah and Zillah. Between A—and Z—he had three sons who fathered a good bit of civilized enterprises themselves. According to the Mosaic legend:

> "Jabal: he was the father of such as dwell in tents and such as have cattle." (Genesis 4: 20.)
>
> "Jubal: he was the father of all such as handle the harp and organ." (Genesis 4: 21.)
>
> "Tubal-cain, was an instructor of every artificer in brass and iron." (Genesis 4: 22.)

If you follow the "begats" in the *Sethite* line you will find another Lamech, who was a son of "old man" Methuselah and the father of Noah. Noah may have been the world's first flood forecaster and shipping magnate! The Mosaic legend continues to say that—

> "Noah began to be an husbandman, and he planted a vineyard. . . ." (Genesis 9: 21.)

and to suggest that he was the first man to become drunk by consuming too much of the wine that was produced on his lands. (Wine in those days was a commodity much like money today!)

So it is recorded in the Mosaic legend that commerce, music, and *instruction in the mechanic arts* had their beginnings in the seventh generation of descendants of Adam by the *wicked* Cain; and that flood forecasting, shipping, and intoxication were introduced at about the same time by a descendant of the *good* Seth.

The span of years between Tubal-cain, "instructor of every artificer in brass and iron," and the engineering teacher of today is uncertain—but certainly it is long. Meanwhile, civilized man practiced irrigation and a crude art of surveying from earliest times, and he must have understood much more of the world about him than we are likely to give him credit for. I shall not discuss the structures, monuments, hydraulic works of the Egyptians and Babylonians; the architecture of the Greeks; the roads, bridges, buildings, aqueducts, baths, and water laws of the Romans; the specifications and contracting procedures of antiquity. I shall not speculate on the knowledge ancient engineers had of rollers, levers, pulleys, and inclined planes; of the theory of arches as well as of the practice of building them to be useful and beautiful for more than two thousand years; of the science of mechanics and its application to arts of peace and war; of geometry and astronomy; of logic, and the mind tracks of induction and deduction; of law to govern rulers and those they ruled; of rhetoric and the art of persuasion; of music and art and sculpture; of the education and training of youth. Yet all

these bear significantly on the advancement of civilization—and with it engineering and engineering education. Who today can expect to have his works live two thousand years from now? Yet that is exactly what is happening to the works of Archmedes in mechanics; of Euclid in geometry; of Vitruvius in building construction and engineering education; of Frontinus in water supply and law.

Heritage of Ideas

In the province of *ideas* it is not always easy to distinguish "old" from "new." Compare ideas about the education of an engineer today with Vitruvius' ideas about the education of an *architectus* 2000 years ago. (Incidentally, the *architectus* of Vitruvius' time is the common ancestor of today's engineer and architect. Since I am speaking of the history of *engineering* education I shall translate the Latin *architectus* into *engineer* and grant that *architect* would be an equally appropriate translation.)

After describing clearly the interplay of craftsmanship and technology in the work performed by the engineer, Vitruvius † suggested how the engineer should be trained. He said, in effect, that engineers "who without culture aim at manual skill cannot gain a prestige corresponding to their labours, while those who trust to theory and literature obviously follow a shadow and not reality. But those who have mastered both [skill and culture], like men equipped in full armour, soon acquire influence and attain their purpose."

The engineering student, he added, must have both a natural gift and also readiness to learn. For neither talent without instruction nor instruction without talent can produce the perfect master. [The engineer] should be a man of letters, a skillful draftsman, a mathematician, familiar with historical studies, a diligent student of philosophy, acquainted with music, not ignorant of medicine, learned in the opinion of lawyers, familiar with astronomy and astronomical calculations. . . .

To those who would wonder that anyone could master so many subjects Vitruvius said that all these studies "are related to one another and have points of contact. . . . For a general education is put together like one body from its members. So those who from tender years are trained in various studies recognize the same characters in all the arts and see the intercommunication of all disciplines, and by that circumstance more easily acquire general information." What more need be said of continued learning. . . ?

Vitruvius stressed the importance of being "fair-minded, loyal, and what is more important, without avarice; for no work can be truly done without good faith and clean hands. Let [the engineer] not be greedy nor have his mind busied with acquiring gifts; but let him with seriousness guard his dignity by keeping a good name." What more need be said of ethics?

We would be smug to assume that our ideas on engineering education today are so far ahead of ideas the Romans had 2000 years ago. We would be a little less than stupid to ignore other parallels between great peoples who lived and worked at opposite ends of twenty centuries of the Christian Era. To illustrate what I mean let me merely allude to such books as "The Wisdom of Confucius," by Lin Yutang; "Vitruvius on Architecture," by Frank Granger; "Frontinus and the Aqueducts of Rome," by Clemens Herschel; "The Notebooks of Leonardo da Vinci," by Edward McCurdy; "The Works of Francis Bacon," by Basil Montague; "The History of The Inductive Sciences," by William Whewell; "The History of Magic and Experimental Sciences," by Lynn Thorndike; "Aims of Education and Other Essays," by Alfred North Whitehead; "Conflict of Studies and Other Essays," by Isaac Todhunter; "Too Much College," by Stephen Lea-

† *Vitruvius on Architecture,*" Vol. I, Book i, Edited and translated by Frank Granger. Harvard University Press and William Heineman, Ltd. (1945).

cock; and—a current gem—"Engineers and Ivory Towers," by Hardy Cross and Robert Goodpasture.

The Romans reached front rank among civilized peoples about the first century A.D., and the end of their decline is usually marked by the burning of Rome near the end of the fifth century. The decline was a gradual process involving "bread and circuses"—more "bread" following more "circuses" in a dizzy spiral. People were unable or unwilling to see the inevitable dangers of political programs that give away "benefits" and take away personal rights and self-respect—and people and politicians coasted to destruction. The fall of Rome was brought about more by the fiddling of Nero and his predecessors than by the actual burning of the city of Rome!

Advancement in Medieval Times

Western Europe fell apart after Rome lost its lead, and a thousand years passed before a widespread revival of cultural progress was ushered in by the invention of printing in the fifteenth century. But this thousand years was not wholly dark. The monks made great efforts to keep civilization alive. One mendicant order, Brothers of the Bridge, built and maintained roads, bridges, and wayside shelters. "Ingeniators" or master builders were in great demand to build private homes for the nobles and to make and operate engines of war. The name "engineer" came into being for ingenious men who did engineering work. I need only to mention such names as Roger Bacon, John of Salisbury, Abelard, to suggest that science and education were not dead in the twelfth century either. Great changes were taking place with action of the Crusades counteracted by the knowledge that followed them back out of the East. Gunpowder had been invented and its use in war sounded death to the medieval castle. One common soldier with firearms was more than a match for many nobles in heavy armor!

A great revival of art and learning started in Italy, and it soon spread beyond the Alps. The mariner's compass was invented—and with it came new courage to explore more unknown worlds. A science of mechanics was firmly grounded—and with it came new courage to explore more of the world's unknown. Indeed, when Galielo was born in 1564 (about fifty years after Leonardo da Vinci died) the world was more than half medieval—and when he died in 1642 (the year Newton was born) the world was more than half modern. Good books were being printed and widely disseminated. The minds of men were as great as they have been in any age—and once they were free to think, they thought great thoughts that brought some of the greatest advances in all time. At the end of the medieval period the old art of casting bells and cannon was reborn as the art of making machinery and metal cylinders The modern world was being born—and among engineers and scientists who helped with the delivery are such men as Copernicus, Leonardo da Vinci, Stevinus, Galileo, Huygens, Newton, Pascal and Vauban

Progress in Modern Times

Before the eighteenth century, training for engineering was by apprenticeship. If you can get the right masters and apprentices together there is no better method; but it is not geared to handle large numbers of students. Schools for engineers grew out of the need for more well-trained men than the apprentice system could provide. It was the French who led in the development of engineering as an art-science in schools of higher learning, and other Europeans and Americans soon followed their lead.

Perronet, engineer to Louis XV of France was given the job of building a system of national highways. Realizing the importance of good technical training, he transformed his staff into a school of men working together in 1747, and this school was legalized and officially named the École des Ponts et Chaussées in 1775. Because of this, Perronet is

sometimes called the father of engineering education.

Great economic and political changes were taking place in France and America in the late eighteenth century. Equally great changes were taking place in engineering—in manufacturing, transportation, commerce, and agriculture. The spinning jenny and steam engine were invented and later the cotton gin. The industrial age had begun. A new shingle appeared in the professional world: John Smeaton, "civil engineer," had coined a new adjective to distinguish one branch of the engineering profession from another. Two famous technical schools were founded in the latter part of the eighteenth century: the Bergakademie at Freiberg in Saxony in 1766 and the École Polytechnique at Paris in 1794. Even so, engineers in England were trained by apprenticeship for many years.

American state universities came into being with the laying of the cornerstone of the University of North Carolina in 1793. The first student was Hinton James ‡ who became a civil engineer. He entered the University early in 1795, was graduated in 1798, and left in a "record book" the titles of original and "exceptionally meritorious" compositions that he presented on Saturdays. Little is known of subjects he was *taught* as a student; but the titles of his original compositions show that he *learned* science, business, and economic geography—sound preparation for civil engineers of his day. Later he became assistant to Chief Engineer [Robert] Fulton on navigation work, and superintendent of work for improving the Cape Fear River.

In America, where so many men have entered state universities, it is interesting to note that the *first* was to graduate and become a good civil engineer!

In the early 1800s power was applied to transportation, and all industry in Europe and America advanced rapidly. More technical schools were needed to train men who could lead and guide mechanized industry. In 1802 the United States Military Academy was established at West Point—modelel after the École Polytechnique. It was the first school of applied science in any English-speaking country. Other schools began engineering training: Polytechnic Institute of Vienna, 1815; Norwich, 1819; Royal Polytechnic of Berlin, 1821; Rensselaer, 1824; University College, London, 1840; and Harvard, 1847.

Formal engineering education now had taken firm root—even if it was highly mathematical and dealt largely with theory. Leadership was being transferred from continental schools to the United States. It is in our own country that we find real progress in formal engineering education during the next hundred years beginning in 1852.

1852–1859

In 1851 the first international exhibit was held in London. Industrial products from many countries were displayed and there was increased interest in technology. The American Society of Civil Engineers was founded in 1852, and engineering education went forward rapidly. After Yale added engineering to its program of study in 1852 and Michigan in 1853, there were six schools of engineering in America—and all of them are active today.

B. F. Greene, director of Rensselaer, studied methods and programs of engineering education in Europe and reorganized work at Rensselaer. In 1855 he published at his director's report, *The True Idea of a Polytechnic Institute*—a classic that merits study today. It is natural, he wrote, to question the utility of such studies as rhetoric and philosophy to technical men when the time spent in formal engineering education is so short. Yet there should be balancing elements in a course necessarily so materialistic. No studies, he reasoned, are more suitable than these [rhetoric and philosophy] for developing the mind and they should find a prominent place in the educational program of every polytechnic institution.

‡ I am indebted to Professor T. F. Hickerson for information about Hinton James.

Rensselaer was thus firmly established as a technical university and was influential in shaping engineering education in America.

1860–1879

In 1862—midway in the War Between the States—the First Morrill Act granted land for colleges of agriculture and mechanic arts. The number of publicly supported schools grew and each one that received land grants included engineering in its programs. Many private schools followed this lead. In the ten years before 1862 the number of engineering schools had grown from four to seven or eight, and by 1870 to seventeen. After the close of the Franco-Prussian War in 1871 there was increased activity in science and technology in Europe and this was reflected in the United States. The number of engineering schools had increased to 70 by 1872.

In a paper on "The Education of Civil Engineers," T. C. Clarke told members of ASCE in 1874 that the educational program should stress learning general principles in the schools and acquiring technical knowledge in practice. This was a highly controversial issue among engineers in 1870's. A. L. Holley argued the other side in a paper on "The Inadequate Union of Engineering and Science" read before the February 1876 meeting of The American Institure of Mining Engineers (founded in 1871). Engineering schools were laying too much emphasis on abstract principles, he argued; and he advised putting the actual practice first and the theoretical study later. Debate was brief but sharp, and the issue was referred to a committee to continue the discussion at a joint meeting of ASCE and AIME at the Centennial exposition at Philadelphia in June 1876.

Twenty-five engineers, prominent in education and practice, took part in this two-day discussion at Philadelphia. The concensus was that education to prepare real engineers must be broad—stressing essential underlying principles and a considerable range of so-called cultural studies. Practical training was also necessary early in the professional life of the engineer.

1880–1899

The exposition of 1876 in Philadelphia was the first in the United States, and it stimulated widespread interest in science and engineering. It is not surprising then that the number of schools which taught engineering increased to 85 by 1880.

The Second Morrill Act of 1890 provided further support for colleges of agriculture and mechanic arts. When the World's Columbian Exposition was held in Chicago in 1893, engineering was taught in more than one hundred schools, and interest in engineering was still growing. The Society for the Promotion of Engineering Education was organized under the chairmanship of Ira O. Baker, professor of civil engineering at the University of Illinois, as Section E of the World's Engineering Congress. Papers at that meeting were presented by men inspired—indeed it is a humbling experience to reread Volume One of *Engineering Education*, dated 1893.

1900–1919

In 1907 the Society for the Promotion of Engineering Education invited the "Founder Societies" in engineering and the American Chemical Society to appoint delegates to a joint meeting to report on the appropriate scope of engineering education and on the degree of co-operation and unity that might be advantageously arranged between engineering schools. The Carnegie Foundation for the Advancement of Teaching and the General Education Board were invited to appoint delegates the next year. The members of national technical societies, asked to express their opinions of the essential characteristics of an engineer, rated them in the following order of importance: 1. Character, integrity, resourcefulness, initiative. 2. Judgment, common sense, scientific attitude, perspec-

tive. 3. Efficiency, thoroughness, accuracy, industry. 4. Understanding of men, executive ability. 5. Knowledge of fundamentals. 6. Technique of practice and business.

C. R. Mann said in 1917 that the division of time in the 125 schools studied was 20 per cent to the humanities, 30 per cent to mathematics and basic science, and roughly 50 per cent to technical work.

By 1918 Dr. Mann's investigation was completed and his final report, *A Study of Engineering Education,* was published by the Carnegie Foundation for the Advancement of Teaching.

1920–1939

In 1922 the Council of SPEE proposed that another investigation be made of the objects of engineering education and the adequateness of the curriculum. Carnegie funds, and others, were granted. W. E. Wickenden was named director of the investigation and H. P. Hammond, associate director in charge of relations with engineering colleges. Many organizations and faculty committees helped in securing data and submitting reports.

The two-volume *Report of the Investigation of Engineering Education,* 1923–29 reached four main conclusions: 1. An undergraduate course should be a coordinated program of three stems of subject matter: science, engineering methods, and social relations. The last year should be focused upon the students' major subject. 2. The three stems of engineering education should be unified into one branch with unity of administration. 3. An undergraduate course should be four years in length. 4. A graduate should continue his development either by formal graduate study in a school or by individual study after he enters practice.

The Wickenden-Hammond reports guided engineering education through the post-war years of the 1920's and the depression of the 1930's. When he was president of SPEE in 1933, W. E. Wickenden said that during the ten years of the Investigation engineers had acquired an envied position among college teachers. A sense of unrest and uncertainty had given way to a sense of assurance. These were the happy fruits of the Board's wise policy of promoting a program of stimulation, rather than one of standardization.

But engineering, which had given birth to many industries, was itself feeling the pains of growth and social pressure during the 1930's. Engineering education had to examine itself again in its social and economic surroundings of the early 1940's. Charles F. Scott may well have set the stage for a new appraisal when he wrote: "What are the causes leading to new trends? . . . Our environment—the world about us—is changing. The science which engineers apply is expanding. . . . Development of engineering education depends upon the willingness and ability for adaptation to changing environment. . . . Is it to be . . . education via the scientific, engineering route, or specific engineering via the educational ladder?"

1940–1952

H. P. Hammond was chairman of the SPEE Committee on Aims and Scope of Engineering Curricula which published its report in 1940. The committee stated that the flexible four-year undergraduate curriculum, followed by graduate work, would meet needs better than a longer undergraduate curriculum; that the undergraduate curricula should be made broader and more fundamental through increased emphasis on basic sciences and humanistic and social studies; that there were advantages in the parallel development of the scientific-technical and the humanistic-social sequences of the engineering curricula; that the integrated program which extends throughout the entire undergraduate period should therefore be preserved.

Soon after the Hammond report was published the United States was a participant in World War II, and every engineer—student, teacher, and practitioner

—was buffeted by crises, hullabaloo, and an avalanche of directives. Engineering educators were bedeviled by changing winds. What lay ahead? What might be the pattern of engineering education after the war? Robert E. Doherty, then president of Carnegie Institute of Technology and president of SPEE, appointed a committee on engineering education after the war, and again H. P. Hammond was selected as chairman. The committee, reporting in 1944, found that the specific purposes are essentially those recommended in the 1940 report on Aims and Scope of Engineering Curricula. They advised that the humanistic-social stem should require a minimum of 20 per cent of the student's time and noted that unless instruction included the elements of practice, it would be in science rather than in engineering. Events had shown one major extension to be needed: a more positive indoctrination in civic and professional responsibilities.

Engineers Keep Pace

From legendary times until today, no men essential to human progress have kept in better step with the vicissitudes of civilized progress than engineers and their teachers. At the close of World War II college enrollments were decimated—and a few years later their burdens were increased more than tenfold. Yet they have not only survived this torrent of change—they have periodically taken their bearings in the light that history and mastery of their profession gives them—and they have projected into the uncertain future, plans which have been realistic enough to make engineering a little better, and our standard of living a little higher through periods of prosperity, depression, and war. In learning to deal with forces of Nature—to get in step with her and apply her laws to the material and economic welfare of all mankind—the engineer learns to deal realistically with things as they are; and he does does not waste too many tears about things that might have been. Our engineering heritage is in large measure the realism and strength and courage that one must acquire if he is to work in the vanguard of inevitable change. In dealing with the caprice of Mother Nature the engineer has been pretty successful; in dealing with the cussedness of human nature he has limitless challenges and opportunities ahead of him.

Who can tell what changes lie ahead? Engineers may study the "laws of politics" in days to come, and harness the overgrown giant of governing machinery which has become America's master, rather than her servant. Would engineers bungle that job more than politicians have done? Time only can answer that. But I would ask one rhetorical question in conclusion: could politicians have done as well in bending the forces of nature to man's convenience and use as engineers have done? The job of harnessing politics for the use and convenience of man is yet to be done—and we'd better begin now!

Centennial Issues of the Journal of Engineering Education

The December and January issues of the JOURNAL OF ENGINEERING EDUCATION contain papers which were presented at the Centennial of Engineering in Chicago in September. Extra copies of these issues can be obtained for $1.00 per copy by writing to the American Society for Engineering Education, Northwestern University, Evanston, Ill.

Achievements in Engineering Education[1]

By THORNDIKE SAVILLE

Dean of Engineering, New York University

Introduction

The achievements in engineering education during the past century are contemporaneous with and an inextricable part of the achievements in the geographical expansion, industrialization, and urbanization of the United States during this same period. It is a far cry from the simple single curriculum in the physical sciences, mathematics, drafting, surveying, and the practical arts of construction available in the half dozen institutions professing to give "engineering" one hundred years ago to the twenty major curricula now accredited in one or more of 148 engineering colleges in the country. The three-year civil engineering curriculum (such as it was) in 1852 has not only proliferated into many specialized four-year undergraduate curricula, but has expanded to substantial post-graduate study and research in many fields.

Faculties have changed from a few scientists and practical men of good will concerned with the problems of transportation and the mechanical arts, to large groups of highly trained specialists versed in the theory and practice of a profession which has come of age. In 1852 there were probably no more than twenty-five or thirty scientists or professionally trained people in the engineering schools. Today there are about 7500.

Undergraduate enrollment increased from perhaps 250 in 1852, to 1400 in 1870, and to a peak in accredited engineering colleges of over 100,000 in 1940. Enrollment in these colleges decreased during the years of World War II, then increased to a maximum of about 230,000 in 1947, and has now (1951–52) declined to about 128,000.

Recipients of the first (bachelor's or equivalent) degree in engineering increased from about 25 in 1852 to over 48,000 in 1950. Declining enrollments since then have resulted in fewer graduates. From about 30,000 in 1952 it is estimated a minimum of some 18,000 graduates will be reached in 1956 with a moderate increase thereafter. During the past century the total number of engineers in the country has increased from a few hundred in 1852 to 7,000 in 1880 to over 400,000 in 1952. The accelerated demand for engineers is well illustrated by the experience of 5 major industries (manufacturing, mining, construction, transportation, and public utilities) in which the number of engineers per 100,000 workers has increased from 150 in 1880 to 1500 in 1950.[2]

Engineering colleges have increased from some half dozen in 1852 to 17 in 1870, 85 in 1880, 126 in 1918, and 148 in 1952. The latter figure refers to colleges having one or more curricula accredited by Engineers' Council for Professional Development. In addition there are over 40 colleges reported by the U. S. Office of Education as offering degree curricula in engineering, not accredited by ECPD.[3]

[1] Address at Centennial of Engineering, Chicago, Illinois, September 4, 1952.

[2] "Employment Outlook for Engineers." Bulletin 968. Bureau of Labor Statistics, 1949.

[3] There are 7 engineering colleges in Canada, whose curricula are recognized by the major Canadian engineering societies. These colleges had 5204 engineering students and 1869 graduates with first degrees in 1952.

Facilities have improved from the rented quarters used for many years by the first engineering school [4] to the respectable laboratories and classrooms of most of the accredited engineering colleges, and to the awe-inspiring and elaborate structures of a few of the great private and publicly supported institutions of today.

This quick review of certain quantitative achievements in engineering education during the last century presents no conception of the qualitative improvements which have taken place. Nor does it reflect the concern of the engineering societies and of engineering educators with changes brought about by the ever enlarging applications of science to industrial and agricultural pursuits and to the health and convenience of the people. These are the responsibilities of the engineer, and the success with which he meets them is dependent in large measure upon the scope and adequacy of his education. The purpose of this address is to describe briefly the major changes which have taken place over the past century, particularly during the last 50 years.

Curricula—The First Fifty Years

Prior to 1870 the chief aim of engineering curricula was to train civil engineers to meet the problems of an era of rapid geographical expansion and of growth in urban population. The instruction was largely confined to mathematics (algebra, geometry, trigonometry, and calculus); a year each of physics, chemistry, astronomy, geology, history and foreign language; two years of surveying, two years of English, and courses in the practical applications of "machines," "constructions," "hydraulic works," "earth work and masonry," and in some cases mining and metallurgy.

The rapid growth of industrialization following the Civil War brought about a demand for more varied, rigorous, and comprehensive education for engineers. This stimulated the establishment of many new engineering colleges and engineering departments in existing institutions. Beteween 1870 and 1890 the number of institutions offering formal programs in engineering had increased from 17 to 110. The Morrill Acts of the 1860's provided a powerful stimulus to the establishment of the Land Grant Colleges, where instruction in the "mechanics arts" rapidly evolved into engineering curricula. A number of schools of mining engineering developed between 1864 and 1880. Mechanical engineering began to emerge as an important separate curriculum in the 1880's, and electrical engineering in the following decade. Chemical engineering was offered by two or three colleges in 1900.

The period from 1870 to 1900 was one of transition. The major curricula in civil, mining, mechanical, electrical and chemical engineering developed in the order named from empirical and so-called "practical" instruction based on didactic teaching in the classroom to what became for the ensuing fifty years the conventional engineering curriculum, namely, four undergraduate years, the first two devoted largely to basic studies in the natural and mathematical sciences and the last two increasingly occupied with specialized courses pertaining to the particular professional discipline being pursued.

Dr. H. P. Hammond has pointed out that "in certain fields of engineering—civil, mechanical, mining—the art preceded the science, whereas in others—electrical, chemical and perhaps metallurgical—the science preceded the art. This evolution reflects itself in the relative extent to which the corresponding curricula have been largely empirical or scientific in nature."

A notable innovation, peculiar to American engineering education, was [5] "the

ECPD has not been requested to accredit any curricula in these schools.

[4] Rensselaer Polytechnic Institute, the progenitor of engineering education in this country, was founded in 1824, and granted the first engineering degree in 1835.

[5] "A Comparative Study of Engineering Education in the United States and Europe." W. E. Wickenden, Bulletin No. 16, The So-

great development in laboratory methods of teaching, a field where American leadership has been especially marked." Another contribution peculiar to engineering education in this country is the emphasis placed upon the economic, management and production phases of engineering, particularly in the development of separate curricula in industrial engineering.

Curricula—The Last Fifty Years

The period from 1900 to 1950 was not marked by any profound changes in either the philosophy or the practice of undergraduate education, except for the inauguration of the "cooperative plan" and the development of formal degree programs given in the evening in a number of the larger metropolitan centers. Both are described in other sections of this paper.

Curriculum Trends

During this past 50 years there has been a rather marked trend toward more rigorous treatment of the professional courses given in the last two years of the undergraduate curriculum. Scientific discoveries and advances in scientific knowledge have necessarily been reflected in their applications to engineering. To understand and to apply this new knowledge have in turn required more extensive study in mathematics and the physical sciences. A trend toward more such study in the undergraduate curriculum has been discernible but not marked during the past fifty years.

Increased emphasis has been given to the social-humanistic studies, but these must remain circumscribed so long as the present type of rigid undergraduate curriculum persists.

The proper and feasible balance between fundamental science, professional subjects, and the "art of engineering" has been a perennial subject of controversy. A description of the situation presented by Dr. Robert Fletcher of the Thayer School of Engineering in a paper before the International Engineering Congress in 1905 is applicable today. "Extreme views are held. Some would have the college programs cover an all-around training in fundamental subjects only, grounding the students in the basal principles of mathematics, mechanics and physical science, and those which determine engineering practice in general, giving due time also to broader culture, but giving only unavoidable attention to details. Others, arguing that this is above all things an age of specialists, would have the student begin to differentiate his studies with reference to some specialty even in the secondary school. Others claim the more common arrangement is necessary and sufficient, that which devotes two or three years of a four years course to the more general underlying subjects, and the final two years or one to study and practice in the special direction. Others argue that the specialty is the life work and should be begun last, and that the schoolwork therein is better done in a fifth or postgraduate year."

The slight trends toward more rigorous upper class subjects and toward more fundamental science in the lower class subjects have been paralled by a marked trend toward an increase in the number of separate undergraduate curricula both recognized and proposed. The five or six basic undergraduate curricula bearing the names of the great "founder" engineering societies began to have "splinters" break off after 1900, just as did the societies themselves. Just as separate organizations were formed for highway, railway, sanitary, radio, refrigeration, safety, power, automotive, ceramic, and other specialists, so newly designated curricula have proliferated in the engineering colleges, and in many cases using similar designations. Today twenty such curricula are accredited by ECPD, and proposals for more have been submitted. This subject is discussed further under the heading of "Accreditation."

The Cooperative Plan

Reference has been made to a notable experiment in engineering education which

ciety for the Promotion of Engineering Education, 1929.

has statistically had a rise and fall during the past half century. The "Cooperative Plan of Engineering Education" was inaugurated at the University of Cincinnati in 1906 by Dean Herman Schneider. This is defined [6] as "an integration of classroom work and practical industrial experience in an organized program under which students alternate periods of employment in industry, business, or government." This plan had considerable vogue between 1910 and 1930, but as late as 1949 only six of the 148 accredited engineering colleges require it for all of their undergraduate students. Twelve others utilize the plan for some of their students, either on an elective basis or for a particular curriculum or group. Eleven accredited engineering colleges adopted the plan, and subsequently abandoned it. The plan is markedly successful in many of the 18 accredited institutions utilizing it for all or a part of their students. It has obvious advantages of the "learning while doing" character. Its success depends upon continuous and rather expensive supervision by the educational institution of the kind of practical work in which the students are engaged and the coordination of such work with the curriculum content at a given time. The failure of the majority of accredited engineering colleges to adopt or to continue the cooperative plan is believed to be due to a variety of difficulties, of which added length of time to receive a degree, greater cost, difficulty of suitable employment in depression periods, and objection of labor unions are among the more important. The increased availability of engineering curricula given in the evening in larger metropolitan centers (discussed elsewhere) provided a less expensive and in part a more realistic substitute for the formal cooperative plan.

Evening Degree Programs

By the early 1920's four institutions in New York City, one in Washington, and one in Pittsburgh had begun to offer formal engineering curricula in the evening for which degree credit was given. The first ECPD accrediting committee had some misgivings as to the adequacy and equivalency of these programs as compared to the usual four-year full-time day program. However, after some study and the reports of special subcommittees, four such curricula were accredited in 1936, three in New York and one in Pittsburgh. By 1951 ECPD had accredited evening programs in only six institutions, three in New York, one in Newark, one in Pittsburgh and one in Cleveland. However, many of the engineering colleges accredited for full time day curricula are offering unaccredited evening programs of substantial size. The six institutions having accredited evening programs reported approximately 6500 students enrolled in 1951, out of a total of 13,400 evening students in all of the accredited institutions. There were 3500 evening students enrolled in evening degree programs in 1924.

The evening programs are primarily designed for those financially unable to pursue a four-year full time day prgoram. Such students are employed during the day time, frequently in sub-professional occupations analagous to those utilized under the cooperative plan. To a degree, therefore, evening programs represent a modification of that plan. The evening programs require a minimum of six years, and customarily six and one half to eight years before the first degree is obtained. These programs, when carefully and conscientiously administered, are proving in all respects the equal of the full time day programs. There are tendencies which have to be watched to be certain that course content, student performance, and quality of instruction are maintained on a satisfactory basis. In some institutions an undue number of students may be enrolled in evening programs who are not primarily interested in obtaining a degree, but are more concerned in the vocational utility of a single course or a few courses.

On the whole, carefully formulated and well administered evening engineering cur-

[6] "A Survey of Cooperative Engineering Education." Bulletin No. 15, 1949, U. S. Office of Education.

ricula are supplying a needed opportunity for students unable to finance a full time day program, and the graduates from these programs constitute an important supplement toward helping meet the demand for more engineers. The programs have been successful in the few metropolitan centers where they have been operated for many years, and there is a real need for the development of additional accredited evening curricula in a good many other areas, particularly where manufacturing industries can supply a sufficient volume of students.

Faculty

Obviously the quality of instruction in engineering is dependent largely upon the calibre of the faculty charged with imparting it. Just as instruction and curricula content have tended to become more rigorous and more specialized, so has the calibre of the faculty tended to become more learned and more competent in special areas of science and technology. The early engineering teachers were scientists or practical men who looked to Europe, and particularly France, for the engineering and scientific texts and treatises which formed the basis for most of the formal teaching. Since 1880, and particularly during the last fifty years, an entire literature of engineering education has become established in this country, which for careful preparation, scope of coverage, theoretical and practical content, and excellence of format has no equal in the world. This literature has increasingly reflected the growing stature of our faculties.

Another index of the accomplishments of the teaching staffs may be measured by the great increase in the per cent of the total number which hold advanced degrees. From the rather sparse and unsatisfactory statistical data which exists it is probable that during the past fifty years the per cent of faculty members engaged in teaching engineering subjects who hold an advanced degree has increased from perhaps 25% in 1900 to about 45% in 1920, to 60% in 1940 and probably to at least 75% at present. Some concern has been expressed lest too great emphasis is being placed upon advanced degrees, particularly the doctorate, as a prerequisite for faculty advancement or appointment to the higher grades. But since the employers of engineering graduates evidence an increasing desire for a greater proportion who have a post-graduate degree, and pay an attractive differential for them, it is essential that the instructors be qualified to prepare such graduates. More important than this, however, is the constantly increasing scope and breadth of engineering which requires the members of a competent faculty to have intellectual and scientific attainments of which possession of an advanced degree provides at least some assurance.

Many professional members of faculties are engaged for a part of the year either in actual practice of their profession or in research in one of its specialties, or both. The great increase in number of faculty engaged in research is mentioned elsewhere, and most engineering colleges today encourage both outside practice and research in moderation. Moreover, there is a constant infiltration of engineers from industry and government into the faculties, a procedure having much to commend it, but increasingly difficult under current conditions of higher salaries in practice. The reverse practice of industry's enticing promising young faculty members away from engineering colleges by higher salaries is a problem familiar to all of us. Some attention is being given to exchange arrangements with industry, whereby engineers in industry and in engineering college faculties will be given concurrent leaves of absence for a year to fill each other's places. Arrangements of this sort, if widely adopted, may do much to broaden engineering teaching and be equally beneficial to the cooperating employer.

The character of the man, the composite of his personality, his professional achievements, his concern about students and about engineering, his philosophy of life, all are important elements in selecting a teacher. The securing of the right kind of teachers has always been a major problem

in engineering education, and it remains so today.

Graduate Study

Prior to 1890 there were only six institutions which had conferred advanced degrees in engineering. Only three earned doctorates had been conferred at the end of 1896. It was not until the second decade of the present century that any substantial number of graduate students were enrolled or post-graduate degrees conferred. Since then the accelerated impact of science upon engineering and technology has created an ever increasing need for engineering graduates who have been educated in specialties beyond the extent possible in a four-year undergraduate program. By 1921 some 40 engineering colleges were offering graduate work, 368 graduate students were enrolled, and 178 post-graduate degrees were awarded. However, some of these degrees were awarded by institutes of technology and were in such fields as chemistry, biology, geology, etc. The first differentiating statistics appear in 1934, when graduate registration totalled about 2800 and post-graduate degrees awarded numbered nearly 1200.

Prior to the outbreak of World War II, graduate registration in 1939–40 had increased to 4582 enrolled for the Master's degree (1318 degrees awarded) and 624 for the Doctor's degree (108 degrees awarded). The phenomenal developments in the applications of science which took place during the war years created a marked increase in the demand for engineers with post-graduate education. The engineering colleges were quick to respond, too quick upon the part of some institutions not adequately equipped in faculty or facilities. Enrollment for the Master's degree in 1951–52 was 16,452 (5134 degrees awarded) and 2875 for the Doctor's degree (586 degrees awarded). It is interesting to note that with a declining enrollment in undergraduate curricula for each year since 1947, there has each year been an *increase* in graduate enrollment.

An interesting comparison may be drawn between evening work on the undergraduate levels. About 10% of the total number of undergraduate students are enrolled in evening programs, whereas 10,000 (52%) of the 19,300 graduate students are enrolled in programs or courses given in the evening. At least 23 institutions have enrollments of over 100 graduate students in evening courses. Nearly all of these are in industrial centers. The magnitude of these evening graduate programs is an indication of the extent to which engineering colleges have met the demand by employed engineers for further education. The evening courses are in some instances given in cooperation with industry (as in the Westinghouse program) and in many instances the employer subsidizes all or part of the cost of the employee's education. Also many students who did not exhaust their veterans' benefits are using this means of acquiring post-graduate education while employed.

Research

Research as performed in engineering colleges may be broadly defined in two categories, (a) that undertaken by faculty members and graduate students to advance knowledge and supported by institutional resources or by grants from foundations, and (b) that sponsored by government agencies or private industry. Prior to World War II the major research activities of the privately-endowed institutions were predominately in class (a), and class (b) sponsored research was performed chiefly in the land grant colleges through their engineering experiment stations.

Before 1940 research was recognized as contributing significantly to education in attracting scientifically minded men to the faculties, in the stimulus it gave to instruction, and as a necessary element in post-graduate education. However, nearly every report of groups investigating engineering education from time to time deplored the meagerness of research activities at all except a few of the larger or more enlightened institutions. Beginning about 1940 in a few institutions peculiarly

adapted for research in special applications of science to the war effort, the support of research by federal government agencies has reached large proportions and is distributed among a good many engineering colleges. Nearly all are seeking more.

The contributions of the engineering colleges to the applications of science to new developments and processes have been tremendous during the past decade. A great service has been rendered the nation, and many institutions, faculty members and students have benefited in various ways. No longer may it be said that engineering colleges are not sufficiently alert to research. But the availability of such great amounts of federal funds for sponsored research has brought its problems to the colleges, problems of some magnitude and not yet resolved. Among them are dangers from the preoccupation of some faculty with research projects to the detriment of good teaching; the assignment of good teachers to research projects for all or a significant portion of their time; and the restriction of federally-supported research programs to those of interest to a given agency, to the detriment of prosecution of more basic or fundamental research on which faculty members might prefer to be engaged.

From what has been said above, the question will at once be asked: What has industry done to encourage research in the engineering colleges, one of whose major functions is to supply industry with well-educated personnel? Unfortunately, and somewhat illogically the answer is: an insignificant amount when measured by its reliance upon engineering education for its present existence and its future performance.

The leaders of industry have naturally and properly been alert to decry the tendencies toward a socialistic or paternalistic state, and argue for more reliannce upon the "free enterprise" concepts of our original democracy. Yet, although engineering provides both the intellectual and physical basis of industrial design, production, and management, the support of engineering education through wise policies of assistance without attempts to control, has been stranngely lacking on the part of a considerable segment of our business community other wise notable for its prescience.

Industrialists have been frank, and often indiscriminating if not ignorant critics of engineering education. They have been prompt to support measures to ensure their continued supply of engineering graduates (as within the present framework of the Engineering Manpower Commission), but they have conjured up every conceivable argument and legal device to excuse them from any considerable support of the educational institutions upon whose graduates their future is based. To research, which might be supposed to represent an area of support which would offer a quid pro quo, their contributions on the whole have been relatively small in amount and not administered according to any broad policy. To be sure some industries have made fairly substantial grants for research usually in some developmental field of direct interest to them, but the support of basic research in engineering has been extremely meager considering the vast industrial interests involved. The support of graduate fellowships by industry has been somewhat better, and a real achievement has taken place in the past few years with the establishment of a number of quite generous fellowships by a few large industries with no strings attached. Doubtless the situation is not entirely the fault of industry, and there is need for Engineering Education to do more to convince industry that its support of research is warranted on a much larger scale than has been experienced heretofore.

Out of the present situation there will undoubtedly emerge more rational and yet adequate policies and procedures which will enable the engineering colleges to give to research its proper place in a broad program for engineering education which it is their chief concern to formulate and continuously to improve.

Auxiliary Educational Services

The major obligation of engineering education is to develop graduates who are competent to practice and to lead in the profession. However, from time to time engineering educators are called upon in the interest of the public welfare or safety to render educational services auxiliary to professional education. For many years engineering colleges, particularly those supported by public funds, have operated courses of relatively short duration for the training of sub-professional personnel. The "short schools" for water works operators, highway personnel, power plant operators, and the like have rendered and continue to render a distinct public service.

"During the first World War the engineering colleges of the country were responsible for a major portion of the vocational training programs of the U. S. Army, which was almost entirely concerned with the training of mechanics, and gave practically no attention to training on the engineering level." [7] Except in relatively circumscribed areas, continued production of professional engineering personnel was not regarded as an essential element in winning the war, and the engineering colleges were thus allocated a program of sub-professional character which they performed with versatility and enthusiasm.

Perhaps the greatest contribution of engineering colleges as a group to the prosecution of World War II was the Engineering, Science, and Management War Training program under the auspices of the U. S. Office of Education. "More than 1.5 million men and women received special training during the period October 9, 1940 to June 30, 1945 in short intensive college level courses designed to prepare for technical and scientific work in war industries. . . . The Federal Government expended nearly 60 million dollars to cover the actual costs incurred." [7] This program was conceived, organized, administered and operated by the engineering colleges of the United States.

Two sentences will suffice to describe the ASTP (Army Specialized Training Program) of the latter part of the World War II period. It was conceived by the War Department, a fantastic substitute for collegiate education dreamed up by the military and "professional educators" (not engineering) and designed primarily to produce badly needed engineers for the armed services with some specialists in linguistics and other areas in an abbreviated curriculum. It was a dismal failure from the standpoint of engineering education in which the engineering colleges participated reluctantly both as a national duty and as a substantial alternative to educational oblivion.

Certainly one of the great achievements of engineering education in this country has been its freedom from any dogmatism that its obligations were fixed toward any narrow professional objective. It has continuously demonstrated an adaptability to serve as national needs or military dicta required in times of emergency, and to guide and help in many areas auxiliary to its major purpose in times of peace.

Relation to the Engineering Societies

It may be stated unequivocally that engineering education enjoys a relationship to the engineering societies unique in the annals of professional education. No other profession has any organization of its educational members comparable to the American Society for Engineering Education. No other profession has an association of professional societies devoted to educational and related activities comparable to Engineers' Council for Professional Development. It is not surprising therefore that engineering education in the truly professional sense has developed rapidly since 1893 when the predecessor of the ASEE was established, and that the impact of the profession itself upon the education of its practitioners stems from the establishment of ECPD in 1932. No system of professional educa-

[7] "Engineering Science and Management War Training," Bulletin 9, 1946, U. S. Office of Education.

tion could remain static or complacent when subjected to the constant scrutiny of the committees and divisions of its own members supplemented by continuing appraisals and criticisms from a group representing the major professional societies and the licensing boards of the several states.

The American Society for Engineering Education

The Society for the Promotion of Engineering Education was organized at the Congress of Engineers held in connection with the great World Columbian Exposition in Chicago in 1893. Engineering Education was Division E of the Congress. Professor Ira O. Baker of the University of Illinois was chairman, and Professor C. Frank Allen of the Massachusetts Institute of Technology was secretary. Both were members of the American Society of Civil Engineers, and Professor Allen in rendering his secretarial report stated "that a society had been organized by the members of the Division for the promotion of engineering education." Thus one may say that the Society whose centennial we are now observing in a sense fathered the Society for the Promotion of Engineering Education. Weight is lent to this by the fact that two of the first three and fourteen of the first twenty five presidents of the Society were members of the American Society of Civil Engineers.

The Society for the Promotion of Engineering Education began with 70 members, which has now (1952) increased to over 7000. It early started studies of various facets of engineering education, and initiated in 1907 a practice followed from time to time ever since, a request for the professional engineering societies to collaborate in its major investigations. In that year it invited the societies of the Civil, Mining, Mechanical, Electrical and Chemical Engineers to join it in forming a Joint Committee on Engineering Education,[8] to explore all of the aspects of the subject. The Committee was organized, and the American Society of Civil Engineers in 1908 made an appropriation for its operation, the first recorded grant from an engineering society for an investigation of engineering education. However, the Committee still lacked adequate funds for its investigation. In 1916, the Chairman of the Committee, Desmond Fitzgerald, who was President of the American Society of Civil Engineers, reported that "after we (ASCE) had spent all our spare cash in carrying on the work of this Committee, we naturally turned our eyes to the Carnegie Foundation."[9] The Carnegie Foundation undertook the task, and in 1918 issued a report by C. R. Mann entitled "A Study of Engineering Education."

This report was the first of a number of significant studies and investigations into the general field of engineering education sponsored jointly in one way or another by the Society for the Promotion of Engineering Education (or its successor) and the professional engineering societies.

The Society was reorganized in 1946 to provide for more effective administration and better recognition of the several elements in engineering education; viz. the individual teacher, the work of Committees and Divisions, the geographical sections, administration, and research. The name was changed to the American Society for Engineering Education. The Society has individual membership and also associate membership for organizations having a major interest in engineering, such as industries, research institutes, and the like. It has always had, as active members, many who were prominent in practice, such as presidents, chief engineers, and personnel managers of industry. This has provided important stimuli for many activities, and has introduced an important element of consideration of prac-

[8] The member societies of this Committee now constitute (with the National Council of State Boards of Engineering Examiners, and the Engineering Institute of Canada) the Engineers' Council for Professional Development.

[9] Proceedings, Society for the Promotion of Engineering Education, Volume XXIV, 1916, p. 46.

tical and present needs into its many achievements. The Society has active Divisions constantly concerned with improvements in instruction in the several curricula and the major supporting sciences and non-technical subjects. It has various special committees which have from time to time issued notable reports which have had a profound influence upon engineering education. The best known, most exhaustive and most influential of these was the "Investigation of Engineering Education," a monumental study extending over ten years (1923–34) financed by the Carnegie Corporation, the Engineering Societies, and certain industries. It still forms the platform from which later studies have taken off.

The American Society for Engineering Education is an extraordinary phenomenon in professional education. There is nothing approaching it as related to the other professions. Its achievements and the constant pre-occupation of hundreds of its members with major facets of engineering education are too little appreciated by the profession which it serves. Its annual meetings are attended by upwards of 1000 of its members, where they discuss reports of committees, and papers dealing with new educational ideas or procedures. An enumeration of the names of a few of its Divisions and Committees is illustrative of its concern with current problems. In addition to the Divisions dealing with all major curricula and supporting courses, there are Divisions of Relations with Industry, Graduate Studies, Technical Institutes, etc. Its major committees include Selection and Guidance, Research, Atomic Energy Education, Young Engineering Teachers, and Improvement of Teaching. Its Manpower Committee was the progenitor of the Manpower Commission of Engineers Joint Council. Reference will be made later to a new Committee on Evaluation of Engineering Education.

The publications of the Society have a world wide distribution, and are regarded as authoritative sources of historical background, current practice, and statistical data. They have had a substantial influence upon engineering education in this and other countries.

Engineers' Council for Professional Development

As the engineering profession became larger in numbers, as an increasing proportion of its members were college graduates (from perhaps 25% in 1852 to 85% in 1952), as the engineering societies grew in numbers and influence, a professional consciousness developed which in 1932 produced a need for Engineers' Council for Professional Development. The six societies which participated in the Joint Committee on Engineering Education in 1907 (ASCE, AIME, ASME, AIEE, AIChE, and ASEE) initiated steps to form the Council and invited the Engineering Institute of Canada (EIC) and the National Council of State Boards of Engineering Examiners (NCSBEE) to participate.

The ECPD is a conference body commissioned "to promote efforts toward higher professional standards of education and practice, greater solidarity of the profession, and greater effectiveness in dealing with technical, social, and economic problems."[10] It will be noted that engineering education was regarded as of prime importance, and it has continued to be one of the major concerns of ECPD. This concern has been implemented by the activities of two standing committees over the past twenty years, those on Education and on Guidance. The Committee on Education (originally the Committee on Engineering Schools) has dealt with accreditation of engineering curricula; that on Guidance (formerly Student Selection and Guidance) with information on engineering as a career supplied to secondary school students, and with the determination of aptitudes for engineering study in the development of testing procedures. More recently a new and important committee has been established, that on Ade-

[10] "ECPD—A Challenge." Booklet issued in 1947 by ECPD.

quacy and Standards of Engineering Education.

Accreditation

Engineering Colleges. By 1932 over 135 institutions of higher education were offering degree curricula in engineering. It had become obvious that marked differences occurred in educational standards, the strength and breadth of curricula, the qualifications of faculties, and the adequacy of facilities. Some process of determining the composite of these criteria as a basis for recognition of the graduate as acceptable for membership in the professional societies and for admission to state license examinations was obviously needed. The growth of state licensing laws was beginning to develop a danger that separate accrediting procedures would be set up in each state, with resulting differences in standards and practices and general confusion. Hence ECPD created the Committee on Engineering Schools (now the Committee on Education) to represent the entire profession and the state licensing boards. This was a formidable and delicate task. Hence a distinguished committee was appointed under the chairmanship of President Karl Compton of the Massachusetts Institute of Technology and members representing the participating societies of ECPD. The Committee spent four years in making its initial studies, and published the first general list of accredited curricula in 1937. Of 626 curricula inspected in 129 institutions visited, 374 were accredited for a limited time and 71 accredited provisionally in 107 institutions. Action was deferred on 8, and 173 were not accredited. The Committee has continued its activities, and as of 1951 680 curricula are accredited fully or provisionally in 148 institutions.

There is not space to describe in detail all of the policies and procedures affecting accreditation, but the operations of the committee represent some major achievements in engineering education. Therefore, since the accrediting process has profound implications upon the progress of engineering, and since the rapid increase in attainments required by the engineer and the enlarging diversity of his employment have raised anew some old problems and have created new challenges, a brief resume of the basic principles heretofore applied to the accrediting process is in order.

1. Only specific curricula, not institutions, are accredited.
2. Inspection with a view toward accreditation is made only upon the invitation of an institution.
3. The purpose of accreditation is to identify those institutions which offer professional curricula in engineering worthy of recognition as such, and shall apply only to curricula leading to degrees.
4. Only undergraduate curricula have thus far been accredited.
5. Accreditation is based upon both qualitative and quantitive criteria, but no "standards" have been formulated or applied. Accreditation is based largely upon the over-all judgment of a qualified inspection committee, which applies general criteria listed in each annual report of ECPD.

The original intention of ECPD was to recognize for accreditation only the six major curricula, but as mentioned previously the proliferation of engineering societies was paralleled by a proliferation of engineering curricula. Pressures from the engineering colleges and from segments of the profession itself forced the Committee on Education to recognize additional curricula. The first list of accredited curricula (for the New England and Middle Atlantic states only) published in 1936 expressed the principle that "ECPD will recognize the six major curricula (chemical, civil, electrical, mechanical, metallurgical and mining engineering) represented in its own organization, *and such other curricula* as are warranted by the educational and industrial conditions pertaining to them." This left the door wide open, and in the very first list referred to above fourteen curricula are

recognized, thirteen of which (the largest at any institution) were offered at MIT.

Since then proliferation has continued to be resisted by ensuing ECPD committees, but it has been a losing battle. The latest (1951) ECPD report lists 20 different accredited curricula. Applications are pending from various engineering colleges for recognition of some 15 new curricula, ranging from coal mining engineering to fire protection engineering. All that is needed is a curriculum in combustion engineering and we will have a trinity of engineering specialists, one of which will procure the fuel (coal mining), the next will burn it (combustion engineering), and the third will put out the fire (fire protection engineering)!

Technical Institutes. The provision of appropriate education for those who serve the engineering profession in sub-professional capacities, as engineering aids, technicians, and the like, has long been a subject of discussion. ASEE reports twenty years ago called attention to the importance of such education, and urged the recognition of technic institutes for their necessary and avowed purposes, lest many more be tempted to follow the example of some, and metamorphose themselves into weak engineering schools. Recognizing the importance of technical institutes in the general scheme of technical education, a Division of Technical Institutes was established in ASEE after World War II. In 1945 ECPD undertook to extend the accrediting process to technical institutes which offered two year terminal post-high school programs.

A subcommittee of the Committee on Education of ECPD administers the accreditation of Technical Institutes. Twenty-three are now (1951–52) accredited. The accreditation process is based to a degree upon the criteria described above for engineering colleges, with due allowance for the different type of curricula and objectives. Technical Institutes have come of age. The guidance provided them and the recognition accorded them represent an important achievement by engineering during the past decade.

Yet the role of the technical institute is not yet what it should be in the overall concept of education for engineering and its related technology. The situation is well expressed in a personal communication to the writer of this paper by Dr. H. P. Hammond, who guided the Technical Institute accreditation policies of ECPD through the first five years. He states:

"I think it is significant and important to point out that the number of technical institutes is inversely in proportion to the number of engineering colleges as the need for them exists in this country. Broadly speaking, and with exceptions, they are inadequate also in quality to produce the sub-professional technically trained personnel needed by industry and government. The result is that the engineering colleges are forced to carry a load of what is actually subprofessional training for poorly qualified students who will never become genuine professional engineers. And many colleges are perfectly willing to do it. This is one of the greatest sources of low standards of accreditation. It is the reason I advocated the establishment of the subcommittee on technical institutes and this had some benefits, I think, but it has not accomplished what I hoped it might and it never will unless industry, the profession itself, and the colleges get a new conception of engineering as a professional pursuit and of technical institutes as the appropriate source of subprofessional technicians."

Guidance

The selection of qualified students for admission to engineering colleges has been a matter of study and experiment ever since the Mann Report of 1918 called attention to the promising tests developed by Thorndike and by Thurstone. Subsequently the ECPD has collaborated with ASEE and many engineering colleges in the development and application of various testing programs. The most ambitious was the Measurement and Guidance Project in Engineering Education operated from 1943 to 1948. Substantial financial support was furnished by the Carnegie Foundation. The project was absorbed into the Educational Testing Service when that was created in 1948 to merge a num-

ber of testing programs. Many engineering colleges have used many testing devices to attempt to select better their entering students, and to predict their subsequent performance in engineering. Nearly all have been modified, and experimentation continues. This fact of engineering education contains many unresolved and debatable problems.

Adequacy and Standards

From time to time as engineering expanded as a profession, as it felt the impact of new scientific knowledge, as its graduates were catapulted into fields where applied science or other professional disciplines required both the specialized knowledge and skill of the engineer, recurring controversies have arisen as to (1) the content of the engineering curriculum, (2) its objectives, and (3) its length. Another such period of inquiry and decisions is upon us. ECPD recognized this by the creation in 1950 of a Committee on Adequacy and Standards. Its first report was published in 1951. This report called attention to the wide variation in the quality of engineering curricula, even though they met the minimum standards imposed by the accrediting procedure. It pointed out the need for more adequate knowledge of the fundamental sciences, the different methods in use for relating this knowledge to engineering education, and the basic premise that the "Differentiating characteristic of the engineering function is the ability to utilize the sciences for the creative process of design and development of useful apparatus, structures, or other works. . . ." The Committee suggested a reappraisal of engineering education which is now under way.

Conclusion

The foregoing account of some of the major achievements in engineering education during the past century had perforce to omit many significant developments, experiments, and related topics. It should be clear that progress in engineering education has been substantial, and that the achievements are significant and numerous. But it is equally obvious that serious problems still confront us, of which curriculum content, proliferation of curricula, length of the undergraduate curriculum, post-graduate education, and selection and guidance are among the more important. The ASEE and ECPD have recognized the challenge, and there was established by ASEE in June 1952 a Coordinating Committee on the Evaluation of Engineering Education. The results of this inquiry will undoubtedly mark an important milestone in the future of professional education in engineering.

The major objectives of this important study will doubtless be described in the last papers of today's program. Suffice it to say here that the continued alertness of engineering educators and the engineering societies to meet the ever-expanding requirements of sound and adequate education for the engineering profession has been productive of substantial achievements. But this very alertness and the lack of complacency which has happily characterized these groups, especially during the past half century, have created an awareness that the time is at hand for some serious soul searching to insure equal achievements for the future. There is a ferment at work which has had as its first product the initiation of the evaluation process just mentioned.

The real measure of the accomplishments in engineering education is in the contributions of its product to the profession of engineering. The recognition accorded that profession; the almost fantastic progress in industrial development and production conceived and managed by engineers; the great structures designed and built by them for the comfort, convenience and health of our people; the increased number of great public and private enterprises directed by engineers, have been contemporary with the improvements in engineering education. Indeed achievements in engineering education, resulting in an ever more competent profession, has in no small measure been respon-

sible for the economic and social progress of this country. Engineering is a peculiar profesion. It ranges over a broader and far more diverse spectrum of future employment than any other profession. This makes the professional education of its future members an unusually complex and difficult matter.

It is believed that the important conclusions from any objective appraisal of engineering education over the past century will indicate that its achievements have been real and significant; the changing requirements of the profession have been anticipated and met; those engaged in engineering education have been alert to needs required by circumstance and science, and finally, that as in any forward moving profession, problems of change and adjustment are clamoring for solution in the new period of transition before us. These will be solved by the collaboration of all elements of the profession as other problems have been resolved in the past.

Reserve this date . . . .

June 22-26, 1953

ANNUAL MEETING

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The Technical Institute: Its Relation to Engineering Education and Trade Training*

By C. W. BEESE

Dean, Division of Technical Extension, Purdue University

Periodically and with increasing frequency the Technical Institute type of education under one name or another comes to the fore as a topic of discussion. It is my plan to give some of the background of the Technical Institute in its current form and acceptance, to discuss the Technical Institute as we find it and try to evaluate some of the influences and trends that may give us a clue as to where this particular type of education is going.

Nature of the Technical Institute

There seems to be a more general agreement on the major elements in a description of the Technical Institute than there is at the moment on terms commonly used for this type of education. A 1931 report of the Society for Promotion of Engineering Education entitled "A Study of Technical Institutes" strongly advocates the use of this term. The influence of this report at least within engineering education and engineering has been a tremendous one. When the Engineers Council for Professional Development set up an accrediting committee and procedures for Technical Institutes, much of the Technical Institute concept detailed in the 1931 report carried over to the accrediting procedure.

The Engineers Council for Professional Development publishes in its annual report a detailed statement or definition of the type of curricula included within its accrediting procedure. Because this statement is so important to engineering and engineering education it is quoted completely as follows:

"Curricula to be considered are technological in nature and lie in the post-high school area. They differ in content and purpose from those of the vocational school on one hand and from those of the engineering college on the other. Curricula in this field are offered by a variety of institutions and cover a considerable range as to duration and content of subject matter, but have in common the following purposes and characteristics:

1. "The purpose is to prepare individuals for various technical positions or lines of activity encompassed within the field of engineering, but the scope of the programs is more limited than that required to prepare a person for a career as a professional engineer.
2. "Programs of instruction are essentially technological in nature, based upon principles of science and include sufficient post-secondary school mathematics to provide the tools to accomplish the technical objectives of the curricula.
3. "Emphasis is placed upon the use of rational processes in the principal fundamental portions of the curricula that fulfill the stated objectives and purposes.
4. "Programs of instruction are briefer, and usually more completely technical in content than professional cur-

* Presented at the Centennial of Engineering, September 4, 1952, Chicago, Ill.

ricula, though they are concerned with the same general fields of industry and engineering. They do not lead to the baccalaureate degree in engineering. Such designations as Engineering Aide, Technical Aide, Associate in Engineering, and Engineering Associate are appropriate designations to be conferred upon the graduates of programs of technical institute type.

5. "Training for artisanship is not included within the scope of education of technical institute type."

The ancestry of many points in the above policy can be recognized in the SPEE report. In addition the Office of Education Bulletin No. 228 entitled "Vocational Technical Training for Industrial Occupations" presents a non-engineering description of the Technical Institute type of program.

The Technical Institute program lies in an easily recognized area between vocational training on the one hand and professional engineering on the other. At the same time it is difficult to define specific limits which automatically classify a program in one area or the other. The Technical Institute programs are essentially vocational. So too are engineering and other professional programs which are essentially vocational in their ultimate objective.

An outstanding characteristic of the translation of the major objectives of the Technical Institute training programs is the freedom which educational institutions have exercised in developing curricula and operating procedures. Technical Institute programs are characterized by the strong influence of the objectives for which they are designed. These programs differ one from another in length of training period, the proportion of technical work, and the types of instruction that are used.

Admission requirements, at least for that group of Technical Institutes accrediting by ECPD, are not too different from those for four year engineering curricula. Perhaps less stress is laid upon formal high school education through a recognition that maturity and experience may substitute for high school graduation.

Technical Institute programs are geared to meet the needs of both full time and part time pre-employment training. Specific groups of courses to meet training needs of persons employed in industry are commonly offered as part time evening programs.

The Technical Institute is commonly described as a terminal program. In this sense it means that the graduate is trained for immediate employment in a relatively restricted activity. It certainly does not mean that the Technical Institute graduate is disqualified from continuing his education into the areas of professional engineering. Many have done so successfully.

The distinction between the Technical Institute program and one of vocational training of less than college grade is more readily discernible. The Technical Institute training pays little attention to training in skills. Rather it emphasizes the "why" through adequate study of college level mathematics, chemistry, and physics. The latter technical courses familiarize the student with the applications in industry of these fundamental sciences.

It is becoming easier to recognize the desirable resources of a teacher of technical subjects within a Technical Institute curriculum allied to engineering. In addition to an adequate scientific and professional background the teacher in the Technical Institute must rely upon knowledge gained in practical industrial experience and the application of his technical "know how" to the needs of industry. The Technical Institute teacher frequently enrolls in his classes many persons who are currently employed and whose job experience is considerable. An important aspect of the teacher is his ability to deal with adults in a way that will command mutual respect in the classroom.

Historical Development

The first Technical Institutes in the United States were organized about 125 years ago with somewhat the same objectives though vastly different curricula than we find today. The early needs for technical training arose from the situations in a pioneer country with expanding agriculture and industry. Another instance of the trend toward "practical" training is in the enactment of the Morrill Land Grant Act about ninety years ago.

It was logical that the colleges should undertake the development of technical training. They had existed for a long time, had developed a heritage of prestige, and had the advantage of granting degrees to label their graduates.

Many early Technical Institutes have had long and proud careers. On the other hand a considerable group of schools that started as Technical Institutes abandoned their objectives to become conventional four year engineering colleges. Questions of prestige of the degree, the nomenclature of a college, and the pressure of alumni seem to overbalance the advantages of the struggle for a successful Technical Institute.

The Engineering Science Management War Training Programs sponsored by the United States Office of Education during World War II were essentially a Technical Institute type of training. Many engineering schools introduced programs through the ESMWT procedures and financial support and retained them as post-war Technical Institute curricula.

Present Status of Technical Institute Instruction

The needs for increasing technical education have developed Technical Institute curricula in schools with varied backgrounds. The annual survey prepared by Professor Leo Smith of the Rochester Institute of Technology and published in the Technical Education News classifies Technical Institutes in the following categories and with the corresponding enrollments for 1951–52.

Maritime Academy and Federal Schools	715
State and Municipal Technical Institutes	16,155
Privately Endowed Technical Institutes	11,140
Extension Divisions of Colleges and Universities	7,435
Proprietary Technical Institutes	10,290
YMCA Schools	682
Total	46,417

The above enrollments do not recognize the work done in the junior and community colleges in Technical Institute type of curricula. The junior or community colleges are becoming increasingly important factors in post secondary education especially in certain areas of the far west and of the southwest. The community college must be reckoned with in forecasting the total contributions of the Technical Institute type of training.

The ECPD accrediting program recognizes only those curricula that lie in fields parallel to recognized curricula for engineering instruction.

Need for Technical Institute Training

The current needs for personnel trained in a Technical Institute arise partly from the present shortage of engineers. More fundamentally they are the result of a number of factors that exist in the technological age in which we are living. The United States census shows that an enormous increase in the production of goods and services has been accomplished without a substantial increase in the percentage of the population engaged in gainful employment. Simultaneously a steadily growing proportion of young persons up to 24 years of age are not engaged in gainful employment but are enrolled in schools or colleges.

Production and services are requiring increasing percentages of skilled and semi-skilled employees. Manufactured products are becoming more complex, industrial establishments are larger, and the coordination of their various elements more complicated. A knowledge of how

to handle things is no longer sufficient while knowing how to handle people and ideas is becoming relatively more important.

It is now an accepted fact that for a period of years the engineering schools will be turning out far fewer engineers than are needed in industry. Coincidental with fewer graduations is a stepped up tempo of industrial production which in itself increases the demand for engineers. How many engineers can be absorbed by industry is problematical but surveys indicate that industrial needs are at least twice the number of available graduates.

Most certainly some shortages can be alleviated if fully trained engineers are placed only on jobs that require an engineer's training. It has been customary, probably for very good reasons, to use engineers through a training period on assignments which can be handled by persons with less theoretical training. It is here that the technician, however he may be called, can best make his contribution toward increasing industrial productivity. Surveys from one source or another indicate that industry analyzes its own program and concludes that it can use from two to six Technical Institute graduates for each graduate of a four year program.

Opportunities for technical training strictly within industry are limited in most instances to the acquisition of specific skills and knowledge. Industry is requiring, to an increasing degree, that new employees shall report with fairly well developed specialities backed up by basic training in fundamentals that will increase the ultimate capacity of the employee beyond what was formerly demanded of him.

These factors are general ones and exert their influence on other types of education than the Technical Institute. It is worth recognizing however that the increasing emphasis on technical training, the shortage of engineers, and the trends in education are emphasizing the Technical Institute. Those who plan Technical Institute programs recognize that the needs of industry can be met only through a variety of offerings.

Strengths of the Technical Institute

Professional engineers through their societies and through their industrial employers are exerting a strong influence on the determination of the Technical Institute program within fields allied to engineering. The Engineers Council for Professional Development, representing the engineering professions, has through its accrediting committee set a pattern which requires a high standard of performance.

The Technical Institute has an important element of strength in that it prepares for specific employment assignments with relatively short well integrated educational programs. They are varied in nature because they are specifically designed to meet industrial needs. They prepare young men adequately for their immediate needs and for their ultimate growth into jobs of increasing responsibility.

Because Technical Institute programs are shorter they represent less investment in both time and money between high school graduation and employment in industry. The cost of tuition is small as compared to the availability of young men for technical employment two or three years earlier than if they entered industry as graduate engineers.

The ultimate success of the Technical Institute type of training lies in the individual success of the graduates. These young men enter industry with a training in fundamentals and their application to industrial situations which places them in a position of knowing "why" as well as knowing "how".

Looking Ahead

Every industrial and educational survey dealing with the Technical Institute type of education points to the increasing need for its acceptance in industry, in education, and by the engineering professions. This definitely fixes certain responsibilities.

Additional institutions that can qualify through staff and experience in technical education have opportunities to broaden their resources through Technical Institute curricula. By direct cooperation with industry it is possible to plan short curricula to meet the needs of the increased numbers of youth who are completing secondary schools and who must have further technical training before entering industry.

Technical Institute curricula should present a balance between training for technical competence and that which will enable graduates to deal effectively with people and ideas and to gain an appreciation of social values and responsibilities. Such programs are neither competitive with nor antagnostic to existing vocational programs and professional engineering. Proper coordination of the Technical Institute program with other types of education increase the effectiveness of all of them.

The higher institution which engages in Technical Institute training in addition to the more conventional degree training and research must realize that the Technical Institute program is different in objective and plan of operation but is not necessarily thereby higher or lower in educational values than either vocational or professional training.

The engineering profession ably supported by licensing requirements reserves for itself those levels of professional activity which require the peculiar type of training which the engineer receives in college. While the engineer seeks to multiply his capacities for handling the highest levels of professional competence he must be aware that he can increase his own productivity by assigning responsibilities for many technical assignments to those with less training than a full engineering curriculum. It is the responsibility of the engineer therefore to guide and direct the sub-professional type of training and the sub-professional technician in order that the engineer may be increasingly useful in his professional capacity.

Both the engineering profession and institutions of higher learning jointly share a responsibility to promote greater public and professional recognition of the Technical Institute type of education.

Industrial employers are still beset with the belief that the standard recognition of a post high school training is a degree. Much must be done by pioneers within industry to sell the idea that the Technical Institute graduate playes a useful and important role in industrial organizations. The graduate of the Technical Institute needs recognition in his own right because his competence while differing from that of an engineer is as necessary and perhaps just as important.

Summary

There are many indications that technical training has arrived at a point where the needs of industrial and other aspects of technological development can be more nearly met through an increased emphasis on the Technical Institute type of education. The movement has many elements of strength. Well developed Technical Institutes of many different kinds are acquiring status in education, industry and the engineering profession. There are no basic problems which will prevent the development of the Technical Institute movement. How fast the institute type of training will grow depends upon the acceptance of its potential contribution to our economic achievements.

The Engineer and the Scientist*

By W. F. G. SWANN

Director of the Bartol Research Foundation of the Franklin Institute and Senior Advisor for the Franklin Institute Laboratories for Research and Development

In the company of those representatives of what man has achieved since the birth of civilization stand several hoary-headed patriarchs. There is painting, an old fellow so rich in years that even civilization itself does not cover the span of his life. Apart from a few bizarre distortions of his normal physiognomy representative of modern art, he seems very much as he was 500 years ago. There stands architecture, who reached his zenith when most of the modern world was peopled by beings not far removed from savages. There stands sculpture, at the peak of its perfection two thousand years ago. There stands literature, grown to full maturity in the time of the Caesars. There stands music, younger, it is true, than its companions in art, but old enough to have acquired traditions stemming well into the past.

And in this ancient and dignified company there stands a representative who is little more than a child in years. He is indeed an infant prodigy by the standards of age of his fellows, a prodigy whose brilliance seems to stagger the imagination of all around him. In the last 150 years of his life, he seems to have accomplished in his own field more than has been accomplished by all the hoary-headed representatives of man's genius from time immemorial and indeed 90 per cent of his achievements are products of the last half century. This prodigy, whose name is Science, can be excused if, in looking around him, he does so with a patronizing air and a feeling that if all who are in his company would do things as he does them all would be better done.

In his advice as to procedures this child, Science, speaks in great detail, and as I study his precepts I become alarmed at the ignorance of my forefathers. I feel that there is nothing that they could do which I should not be able to do better. I know quite a little about mechanics and machinery. I know quite a little about the laws governing the workings of things. I know quite a little about how to design things so that they shall behave as I expect them to behave, and I shudder to think of the time when what I know was not known. And then, I receive rather a jolt to my complacency. I look at one of Michelangelo's masterpieces in Rome, and as I gaze at the great dome of St. Peter's I am conscious of a certain fear lest some spirit, conscious of my arrogance, should come to me and say: "Swann, I am commissioned to order you to build another dome like that, with such modifications as will insure that it is not a straight copy." A chill of fear comes over me for I am conscious of the fact that the dome I build will probably fall down. I beg my visiting spirit to wait while I consult an engineer who is skilled in these matters, but he denies me this privilege and says: "No, my friend, you must build it with the knowledge you have. Did not I find your mind, a moment or so ago, comparing its knowledge with that of Michelangelo? Did you not tell yourself that

*Address at Centennial of Engineering, Chicago, Illinois, Sept. 4, 1952, founded upon material presented by the author in *Physics Today*, June, 1951.

even when you were quite a young man you knew more about statics, about the theory of elasticity, about dynamics and about mathematics than was ever known to Michelangelo, and were you not assuring yourself that unless a man knew these things he could not design even a simple building so that it would be secure against catastrophe. It was only when you turned out of the narrow street in which you had been walking and saw Michelangelo's masterpiece that you became a little confused as to your reasoning. No, my friend, my orders are that you should build that dome with the knowledge that you have. After all, do you not know much more than Michelangelo knew about the very things which are concerned in the erection of that structure?" But as the responsibility is forced upon me, my fears grow and I beg the spirit to allow me to talk with somebody. "Perhaps," says my tormentor, "you would like to consult with Michelangelo. Shall I call him forth from the grave for an appointment?" And then as, in bewilderment, I turn to look upon this spirit, I find him looking at me with a humorous smile as he says: "My friend, go your way. You are excused from building the cathedral. After all, the time has not yet come for its visitors to be sent so suddenly to heaven."

And so I departed in some humiliation to meditate upon this comparison of my knowledge with that of the great mediaeval architect.

Acoustics

In order to restore my morale, I decided that before I was commanded again to undertake such a dangerous task as building a cathedral, I would attempt something on a smaller scale, where a little accident here and there would not be so catastrophic. And so I thought of acoustics, for after all the nature of sound is quite well understood. I can work out neat mathematical problems about sound. I can do all sorts of stunts with Fourier series and with differential equation and the like, stunts which would have flabbergasted old Michelangelo. In seeking a focus for my abilities in this matter, I came upon an old violinist who was highly skilled in his art, but knew nothing about science. In fact, after a few words with him, I found that he knew no more about acoustics than did Michelangelo. I said to him: "My friend, I have been watching you play that instrument and I think that I may be able to tell you how to play it better, for I am a student of acoustics and know all about the laws of sound. With my knowledge and your skill, I am sure it should be possible to play the violin better than you play it." "Very well," said the old violinist, "here is the violin—play it." "Oh, please," I said, "not so fast. I wish to start with something much more fundamental. Indeed, I do not know that I wish to use that instrument at all. It seems to me a very stupid instrument, with no scientific background It is strung with a cat's inside and played with a horse's tail. It has a form dictated by no scientific principles and the only information I have been able to find with regard to it is to the effect that the form had something to do with the supposed figure of the Virgin Mary. I would like to study a very simple case first." And so, I proceeded to suspend a simple stretched string between two fixed points in space and to discuss all the various modes of vibration. I explained how the frequency of vibration determines the pitch, how the overtones determine the quality and so forth. The old violinist, much impressed, but much bewildered, said: "All right, here is the bow; now let us play it." On drawing the bow across the string, the old violinist heard nothing, for we all know that a string so mounted would emit practically no sound at all. The old violinist complained that he could not hear anything, but I felt that it was very unreasonable of him to insist upon what, it seems, is the relatively minor matter of hearing something and proceeded to argue that it is much better to understand what you do not hear than to hear what you do not understand. But the old violinist seemed sad about this

matter and went away, a little comforted, however, by the fact that although he may not know what he is doing he knows how to do it.

Start With Simplified Problem

It is characteristic of the ways of the scientific attack to take a simplified problem, and, by studying it thoroughly, hope that one may proceed to understand and control the complex problem. In the field where the man of science has had the matter in hand from the beginning, this procedure has been very successful. Thus, he started with pure academic interest to inquire why electricity was emitted from hot wires in a vacuum. From the experiments of this epoch certain interesting laws developed which incited further research and further experiments. Some of the phenomena were born more or less in isolation and by themselves presented no great individual prospects. However, they were brought together by the man of science, who nurtured their development, watched over their progress, marshalled them from time to time into more efficient groups as regards their potentialities, until finally we have in the world of today, radio, television, and a hundred other things whose operations, if viewed for the first time, would seem so complicated, so unrelated, and so miraculous that no brain would have the courage to interpret them. If we could imagine some super-genius of the inventor kind who, by a rule of thumb and horse sense—it would have to be a very special kind of a horse—had arrived where we have arrived today in the science of electronics, but without knowledge of the basic fundamentals pertaining to the subject, and if this genius presented us with the various pieces of equipment, with sales bulletins telling us how to turn on the switches and manipulate the knobs, we would have a marvelous time for a week; but even if the apparatus continued to function longer, I venture to say that we should have a terrible task if anything went wrong with it, and further improvement in its operation would take place very slowly indeed, if at all.

Now unfortunately the man of practical affairs has not the opportunity, so frequently afforded to the man of pure science, of choosing his own battleground or even the antagonists with whom he will contend. The man of science fashions his weapons and invents them to his liking. Then he seeks an enemy against whom he may use them with the greatest efficiency. Sometimes when victory has been attained, the territory conquered is rather barren, but he may care little for this if the fight has been a good one. Sometimes the acquired territory is rich in values of many kinds, in which case the inventor receives much kudos for the benefits he has brought to mankind. He is given credit for having unselfishly worked for the good of his fellows. Alas, I fear that in this matter there is a good deal of hypocrisy. In 90 per cent of the cases he has worked on the job because he liked the job, as Richard Coeur de Lion fought the Saracens, not so much for holy motives, as for the reason that to him war was the meat and drink of his existence. If the researcher should find that the future gave utilitarian value to his discoveries, he would probably be as surprised as anyone else at such a consummation of his efforts.

As I have said, the practical man has not the opportunity of choosing his territory for the battle, and those who support him are not willing to look far into the future and hazard the belief that what he does today may be of great value then, even if it has no value now. The practical man has to meet the problems as they come to him. Even if some kind spirit should reveal to him the ultimate fundamentals at the back of his problems, it might not be practicable to find the solution for his immediate task by tracing the story from the fundamentals to the end point. Even though the problem might be one of no perplexity in the sense that the train of relationships could be visualized, it might be one of great complexity, so that its solution was not

realizable within the limits of the skill of man.

If I tap this table, I feel that I understand the fundamentals which control the nature of its oscillations. I can write down the differential equations which govern the whole story and whose solution, subject to the appropriate boundary conditions, would represent the last word in the problem. Alas, however, it is probable that in this particular case the solution would be attended by such difficulties of mathematical complication, that no mathematician who had ever lived could solve it. The problem is one of no perplexity but of staggering complexity.

And so it behooves the practical man of science, the engineer, to adopt procedures less ambitious than those of the man of pure science; and as a consequence, there come into being empirical relationships which experiment reveals to represent truths and which could presumably be deduced from more fundamental starting-points if one only had the knowledge and skill to carry out the process. When so deduced, it would frequently appear that the empirical relations are approximations, but approximations so good that nothing better is necessary for the practical end point. One of the reasons for difficulty in relating the empirical rules to the ultimate fundamentals is the fact that those fundamentals have frequently no power to suggest that the things which are neglected in the approximation are really negligible, for they have to be prepared to deal equally well with other problems in which they are not negligible, even though no such problem should present itself among those concerned in the affairs of our universe.

Fundamental Principles

In any domain of scientific knowledge, we are concerned with the basic fundamental principles, which usually take the form of differential equations, and the solutions of problems governed by those principles. The physicist is apt to place the solutions in a role subordinate to the fundamentals. This is a questionable procedure, for the solutions are in a sense richer in law content than are the fundamentals. The fundamentals apply to all solutions and therefore dare not emphasize the special features of any particular solution. Thus, to take an example, the fundamental laws of acoustics, supplemented by recognition of the psychological significances of pitch, quality, etc., govern the course of all sounds which are produced. They govern the course of acoustical phenomena involved in the production of Beethoven's Fifth Symphony and they also govern the acoustical phenomena involved in the singing of "Old Man River" but they have no more power to demand one in preference to the other. Now the musician is very much interested in which composition is being played. Moreover, when he has his compositions, he starts to invent new laws relating to the compositions themselves. He starts to invent laws of harmony and counterpoint. The fundamental laws of wave motion, basic to acoustics, have no objection to our musician's laws of harmony and to what he tells his pupils as to how the compositions should be played, but they take no part in demanding these laws and give the musician no help in his task of formulating them. These laws are laws characteristic of the group of *solutions* of the fundamental laws, the solutions in which the musician happens to be interested. Indeed, I suppose a pure acoustician who was asked to present a concert would demand that a blackboard be placed upon the stage. On the blackboard he would write the differential equations controlling acoustical vibrations. He would turn to the audience and say: "There, my friends, you have it all! Everything that has ever been composed and everything that ever will be composed! I hope you enjoy it! Good evening."

Now the engineer, as distinct from the pure physicist, is a little bit like the musician. He is very interested in the particular problem itself and in the re-

lation of one problem to another. He senses relationships applicable to the particular solutions, which relationships he may very well formulate as laws. The mathematical physicist may be a little annoyed at this and inform him that his various laws are not independent. "Do you mean," says the engineer, "that you can deduce all of them from one of them?" "Oh no," says the mathematician, "they are neither independent, nor will any set of them completely define the remainder. From my standpoint, they are an abominable logical mess." "But," says the engineer, "are they not all right?" "Oh, they may be all correct," saws the mathematician, "but they are like a lot of ill-dressed people. The hat of one belongs to the coat of the other, the shirt of one belongs to the collar of another. They are awful." Now the engineer does not worry so much about this, provided that his laws are of use. He does as much as he can by discovering valuable relations among the various things which he studies and combines these relations here and there, using everything he can get hold of to help him, even the pure mathematics and logic of the mathematician, when he can, and he seeks, with this rather heterogeneous combination of paraphernalia to accomplish what he sets out to accomplish.

And so, in meditating upon our ancient and mediaeval architects, I have to believe that, though unconscious of the general fundamental laws, they nevertheless sensed many things which were true and were able to mould them into a frame of procedure which was sufficiently concrete and self-consistent to serve as a guide in their operations. *We* should feel very insecure in this frame, fearing that something had been forgotten, unless we could see the elements of that frame as consistent parts of the more complete whole.

Seek Better Understanding

The man of science frequently finds himself seeking for a better *understanding* of the law with which he deals. Now this concept of understanding possesses the potentiality of breeding many illusions. I could talk for some hours on this matter, but one example will have to suffice.

In my student and early teaching days, it was the custom to seek an explanation of everything upon a purely dynamical basis. It is true that dynamics itself, at the period of its birth, was not a science which appealed immediately to the intuitions of the scholars of that time. A description of motion in terms of the activities of supernatural beings who carried things about in a manner determined by God was something which appealed much more strongly to the intuitions of the day. However, the collosal achievements of Newton and his successors grew a kind of reality into these dynamical concepts, a reality which, as time went by, became stronger and stronger, so that in the latter half of the last century there were many who felt that so-called dynamical principles represented the ultimate basis of understanding and were themselves fundamental in their claim to be understood without appeal to anything else. He who did not feel in his bones that dynamics was unassailable and obvious in its meaning was an ass, or at best a kind of lunatic devoid of the fundamentals of common sense.

The matter is illustrated by a comment in Sir Arthur Schuster's "Theory of Optics," written as late as 1904, and it must be remembered that Schuster was one of the world's high priests of natural philosophy in that epoch. He writes: "The study of physics must be based on a knowledge of mechanics, and the problem of light will only be solved when we have discovered the mechanical properties of the ether." Writing in another place of Maxwell's equations, he remarks: "The fact that this evasive school of philosophy has received some countenance from the writings of Heinrich Hertz renders it all the more necessary that it should be treated seriously and resisted strenuously."

And so, in my student and early teaching days, it was the custom, following the lead of Maxwell himself and his school, to seek an explanation of electrodynamic phenomena on purely dynamical bases. If we wanted to make somebody understand a circuit with self-induction, capacity and resistance, we would refer to a ball vibrating in a viscous fluid at the end of a spring. We would say: "Now the self-induction in this circuit is like that mass on the end of the spring. This capacity is like that spring. The electrical resistance of the wire is analogous to the viscous resistance of the liquid, and so forth." By thinking of the spring and ball, which we of the older generation felt we understood more or less, we endeavored to accommodate our thinking so as to understand the electrical problem. Today all of this appears to be changed. At an early age youngsters start to play with radios and to acquire quite a little knowledge concerned with the essentials of their operation. This fact has reversed the whole situation as regards reality in the mind of youth, and the youngster of today and the older youngsters who are doing research in our laboratories seek to understand dynamics by showing that it is like electrodynamics. And if the youngster wishes to understand how a ball bobs up and down on the end of a spring when immersed in oil, his teacher is apt to say: "Now this weight is just like that inductance in one of your radio circuits. The spring is like the capacity, the viscous resistance of the fluid is like the resistance of the wire. Now you know that the electrical circuit will oscillate; and in a similar kind of way, the ball and spring oscillate. You know that if the electrical circuit is stimulated by an external force of frequency equal to its own, it will resonate and build up a big amplitude; and for exactly similar reasons, the ball on the end of the spring builds up an amplitude when subjected to an external force which harmonizes with the system in frequency." Thus, since you understand all about the nature of the electrical oscillations of the circuit, you ought to be able to stimulate your brains to the point of understanding why and how a ball bobs up and down on the end of a spring in oil."

No longer does the engineer seek to understand his electrical problems through mechanical ones, but when he gets a mechanical problem, the first thing he does is to seek the electrical analogue and think in terms of that—he seeks the equivalent electrical circuit. And so this concept, reality, is indeed like a chameleon, changing its color to harmonize with the setting of its time.

If I were asked to distinguish as far as possible in a few words between the state of mind of the pure physicist and the engineer, I would, summarizing what I have said earlier, claim that the high spot of the interest of the physicist is the understanding of the relation between the various parts of his science in terms of the minimum number of hypotheses or starting points. If he is a very sophisticated physicist, he will realize that probably no set of starting points has any prior claim to fundamentality other than is implied in this potentiality of representing the minimum of starting points. To the physicist, a good set of laws provides the means through which, by saying few things, many consequences may result. Sometimes the physicist is not so interested in tracing out the consequences of his laws, but the consequences represent the main interest of the engineer and sometimes the consequences themselves, with their interrelations, can form a scheme for the deduction of further useful consequences without very much appeal to the fundamentals. This wide knowledge of the consequences of the fundamental laws can grow a sensitivity to the way things happen and can grow it even in the mind of him who is unacquainted with the fundamental laws. This sensitivity, developed to a high degree, provides what we may call intuition. And so, in meditating upon our ancient and mediaeval architects, I have to believe that, though unconscious of the general fundamental laws, they never-

theless, on the basis of hundreds of years of experience, sensed many things which were true and these they were able to mould into a frame of procedure sufficiently concrete and self-consistent to serve as a guide to their operations.

As distinct from the procedure of the conventional man of science, and farther to the left, as it were, than the engineer, we find the inventor. Frequently the inventor is very hazy as regards the fundamental principles which control the phenomena with which he deals, but he enjoys a certain compensation by the utilization of knowledge of an enormous number of experimental facts and processes which he combines in all sorts of ways in search of the end he desires. There is apt to be a high mortality in the expected achievements; but valuable end products frequently appear, even when, in the light of a strict appraisal of affairs as represented by the scientific knowledge of the day, it would seem that they never should have appeared.

Engineer Stands Half Way

The engineer stands half way between the pure scientist and the inventor. He is not so concerned with harmony of relationships leading back to the simplest form of fundamentals, but he is concerned with the reasons for things in terms of empirical relations, etc., which he uses to guide his thinking. The inventor is for the most part conscious of these relationships only through a strong sensitivity to their results.

The inventor walks in the territory which the man of science has mapped out into regions of assured fertility, dubious fertility, and almost certain sterility. The man of science, and indeed the engineer, are inclined to conserve their efforts by walking in the rather limited realm which, on the basis of the laws with which they operate, represent regions of assured fertility. However, the inventor walks with courage everywhere. He sees a pasture which he thinks has promise. The physicist would explain to him that his reasons for expecting something from that region are invalid, and in 90 per cent of the cases they are, but the inventor walks nevertheless. He walks persistently, so that every now and again he finds some spot which is rich in content, not perhaps for the reasons that he expected, but for other reasons of which he may be only partially conscious. If we should trace his own reasons to their origin, they might constitute a set of heterogeneous associations with no very obvious logical connection, but which, through the scheme of profound regularity inherent in nature, had conspired to give a suggestion which was fruitful in spite of the very dubious foundations upon which the suggestion was made.

There was a celebrated inventor whose employees hung upon the walls of his laboratory a placard which stated as follows: "The poor fool didn't know enough to know that it couldn't be done, so he went ahead and did it."

In seeking to understand the relationship between phenomena as we meet them without an appeal to fundamentals, much use is made, particularly by the engineer, of analogy. Indeed, Maxwell's electrodynamic scheme, as already cited, had as its object the setting up of an exact analogy between dynamics and the science of electricity and magnetism. Frequently, however, analogies take the form of approximations, but when the approximations are established, the practical man rapidly grows intuitions which become sharpened with time and develops, for the realm of the analogy, a set of laws which are self-contained even though their relation to the fundamentals may be hidden.

One has an example of this in matters pertaining to electrical circuits where, provided that the wave length of any oscillations concerned in the circuits is long compared with the dimensions of the circuit, we can think in terms of a certain type of simplification. There grow the concepts of capacity, inductance, impedance, to which the practical engineer, stimulated perhaps by rivalry with the medical profession, feels the urge to add

another number of godforsaken words, such as admittance, transconductance, etc. While seeking to stimulate my sarcasm in this connection, I have thought of a new term "abuttance." I present it to the radio engineers in the hope that they will find a meaning for it. At present it is like the doctor's discovery of a "cure" for which there is no disease.

In terms of the simplified laws, the practical man proceeds to manipulate these various quantities and to become very clever at predicting what will happen in this case and in that. Occasionally, however, situations arise in which the simplified laws no longer are adequate. The practical man does something about this by making some kind of correction as far as possible in the language of his old formulation. As knowledge advances, however, more and more of such cases arise and the patches on the patched up framework become more obvious than the framework itself.

Engineer Must Acquire New and Strange Tools

As more and more of the fruit of nature's richness becomes plucked, more and more of the potentialities of empiricism, founded upon the structure of matter in bulk, become exhausted, and the more do we have to look to the sub-grained atomic and nuclear structure of matter for further progress. This necessity of an appeal to fundamentals has made itself obvious in electronics, where, however, these sub-grained matters have made their appearance with such subtlety that even the practical man has become inveigled into thinking in terms of them and to walking in a territory which would have filled him with fright if he had been thrown into it all at once. And now, these sub-grained matters are invading other realms, the realms of metallurgy, where new things about the strength of materials, the nature of friction, etc., are only capable of being understood in terms of laws about atoms and molecules and laws, moreover, involving ideas born of such relatively abstract things as the quantum theory of atomic structure. The time is coming when the engineer will find that the sharpening of his old tools is not sufficient for his task. He must acquire new and strange tools, tools which seem antagonistic to his common sense. But common sense is a curious attribute. In its proper domain, it is a jewel of priceless value, but when strongly entrenched in any realm, it can impede progress. Fortunately, it is a changeable kind of thing, and it will happen in the future, as it has happened in the past, that the common sense of the past is the nonsense of today, and the apparent nonsense of today is the common sense of the future. It is for the young engineers, or at least for those of them who are concerned with some of the most interesting aspects of future developments, to attune themselves to the common sense which is to come, that they may walk with the same security under its guidance as their predecessors have walked under the guidance of the common sense of their day.

National Science Foundation News

Edward McHugh, director of the Division of Research and Industrial Service, has announced that the **National Science Foundation** has made a grant of $10,200 to **Clarkson College of Technology** to sponsor research on "Mass Transfer Coefficients and Interfacial Areas in Packed Columns."

James H. McMillen has joined the staff of the **National Science Foundation** as a member of the physics staff of the Division of Mathematical, Physical and Engineering Sciences. He comes to the Foundation from the **Naval Ordnance Laboratory**, where he was chief of the Hyperballistics Division.

Looking Ahead in Engineering Education*

By L. M. K. BOELTER

Dean of Engineering, University of California at Los Angeles

Looking ahead in Engineering Education is indeed a precarious undertaking. The existence of a temporal region of experience from which a rational extrapolation may be made is postulated. To this end the author has relied heavily on the historical data presented in the reports of the American Society for Engineering Education (1). Evidence of lag in effectuating ideas of engineering leaders and of cyclic repetition (probably of period equal to a generation) as well as the lack of the application of the experimental method to pedagogical procedures and to curricular changes may be found in the literature, including college catalogs.

Again, the earlier lack of acceptance of Engineering in the universities of the United States † has left vestigial scars and other effects which are manifested in the academic organizational structures and academic attitudes. The establishment of the Land-Grant Colleges and the early Institutes of Technology had a salutary effect upon the position of Engineering in the Higher Educational Structure of the United States.

The first works of Engineering rest in antiquity. The works of Engineering and Architecture can hardly be separated at the beginning. The great accomplishments of the ancients shall not be recounted here but it will be observed that the progenitor of the Modern Professional Engineer was not always required to conserve national resources or to practice economy. On the other hand, he had much less power available to perform the assigned tasks. Again the early engineer expended a goodly amount of energy developing engines of war.

The transmission of knowledge in the early days was either through shrewd observations of the existing engineering works or through the master-pupil relationship, although certain records were maintained also.

The first American engineering curricula (1) may be characterized as applied science containing a liberal core of sociohumanistic studies. Shop courses were introduced fairly early and remained in one form or another in many curricula for at least two generations. Engineering laboratory instruction was also begun early in the period of the germination of engineering instruction, approximately 1870.

Throughout the succeeding years a gap grew between the sciences (Physics and Chemistry particularly) and their application in the Engineering courses and in the profession. Engineering curricula could no longer be characterized as applied science. Rather, Engineering emerged as a science in its own right and in addition great stress was laid upon the art of Engineering. But the bases upon which Engineering Instruction were built did not change with the change in philosophy and content of the Physical Sciences. Thus a gap of approximately one generation developed between knowledge as added to the Sciences and its application in Industry, which gap was reduced to several years during World War II.

* Presented on September 4, 1952 at the Centennial of Engineering, Symposium on Engineering Education and Training, Chicago, Illinois.

† The same phenomenon was exhibited in Germany (2).

Parenthetically, developments in the Physical Sciences have, however, resulted in the creation of new Engineering Curricula. This gap between the formulated and experimental knowledge of the Physical Sciences and the content of engineering courses and the application to the design of Engineering systems cannot again be allowed to develop.

Segments of the Physical Sciences may be neglected in the Science Departments; these areas must be assumed by Engineering but their assumption should not prevent the transmission of new knowledge of the Physical Sciences into Engineering.

Unterstützungen of the Curriculum

The four-year professional undergraduate curriculum is still considered to be a standard and has proven satisfactory.* However, supports for the curriculum, quintuple in number, will be developed so that the four-year curriculum will remain "a unique segment" of Engineering education.

1. A considerable body of opinion now exists to the effect that at least two years can be substracted from the pre-college school experience (3) of a student who has the intellectual capacity for college work and who also possesses the necessary physical stamina. In other words, the same material now presented can be compressed into a lesser time or the equivalent of two years of appropriate work may be added between the kindergarten and high school graduation. Canadian and European experience will aid to point the way.

The subject material to be introduced in the two years saved will receive careful attention. The University of Chicago in the University College has studied intimately the recasting of knowledge (4), the emphasis on particular modes of reasoning, and desirable methods of instruction (5).

2. The work-study program (often formalized and called the cooperative program) deserves much more thoughtful attention and support. With a slight change in the college calendar and scheduling of all required courses each term, students may be given the opportunity of industrial employment of technical level commensurate with their maturity, training and education. Briefly, an industrial (or governmental) organization will set aside one job which either two, three, or four students will serve seriatim each year depending upon the college calendar. The undergraduate professional curriculum demands the support of this program for survival.

3. The Engineering profession will encourage and develop an internship program to begin directly after the award of the Baccalaureate. Certain industrial organizations have made great strides in post-graduate study for their employees for instance see (6). But the profession has not yet effectively and formally recognized a post-bachelor's program for the training and education of a professional engineer. NOTE: The Engineering Societies require a certain number of years of "in responsible charge" and certain State Laws require that engineers-in-training serve under registered professional engineers.

The College of Engineering, the Employer, and the Engineer-in-training (or Junior Engineering) acting in concert would, in the following tentatively presented plan, arrange an individual program consisting of part or of all the following components:

a) On-the-job employee instruction by supervisors.
b) On-the-job self study.
c) On-the-job courses.
d) Off-the-job courses, socio-humanistic and technical.
e) Off-the-job self study.

The program will be designed to aid the engineer-in-training to achieve professional status, to insure more effective performance of the job assignments during the training program and to fill such gaps in general knowledge and specific applica-

* Certain Colleges of Engineering maintain 5 year curricula at the present time, for example, Cornell University.

tions as will allow the most effective discharge of his duties as a citizen.

An examination or/and a dissertation based upon the total training and educational experiences of the candidate for the previously selected period (say four to five years) will climax this internship program. The initiation of this program at an early date is imperative to the future well-being and strength of the profession.

4. The post-graduate education of the engineer-in-training and that of the professional engineer will receive attention through an intensified adult education program, sponsored by Engineering Extension. Technical courses designed to (a) broaden the engineer, (b) specialize his experiences and general courses designed to give depth and meaning to his contributions to society will be available. Correspondence courses designed to meet specific needs will be had more generally. Techniques will be designed to aid the engineer who is located in out-of-the-way places both domestic and foreign. Publications of the Engineering Societies will be utilized to increase the pertinence of the post-graduate educational experience.

5. Finally a dynamic graduate program leading to either Science or Engineering degrees is in a virile growth stage. Graduate work in Engineering assumed a master-pupil relationship in its early days with emphasis on the original individual investigation. Accompanying its growth will come a recognition that a change of method of instruction is necessary. Courses are now replacing seminars, instructors are undertaking the direction of many research projects; the result in many instances has been that graduate work either has become an image of undergraduate instruction or has retained the master-pupil relationship but on a larger scale and in either case the effectiveness of the instructional methods must be examined.

Graduate students may wish to obtain a foundation which will allow them to practice the Engineering of Tomorrow for which a knowledge of the modern concepts in the Physical and Life Sciences is essential. Others may wish to broaden their base in engineering while still others may wish to specialize in a branch or phase of engineering. Combinations of the three objectives, although resulting in dilution, are also a possibility.

As graduate work in engineering becomes an accepted part of the training and education of the professional engineer the present dichotomy will be resolved through the development of two paths toward advanced degrees.

The M.S. and Ph.D. degrees (or their equivalent) will be directed toward the discipline of research, with emphasis upon the techniques of analysis and with the subject objectives either chosen to decrease the gap between the Physical and Life Sciences and Engineering or selected to broaden the student's background in engineering. In summary, this graduate experience may be designated as existing in the area of Engineering Science.

The other stem, clearly a professional stem, leading to the degrees Master of Engineering and Doctor of Engineering will be directed to the discipline of the design of engineering systems with emphasis on the techniques of synthesis and with objectives of either broadening or deepening the student's background in engineering. This graduate experience may be designated as existing in Engineering as an Art strongly supported by Engineering Science.

In both paths (the word curriculum is avoided in designating graduate work) the methodology of engineering will be employed and a greater emphasis will be placed on its socio-humanistic content. Other professional groups, for instance, medicine at one University, are now administering these two graduate programs seriatim with the professional sequence coming first.

Graduate programs designed for full-time professional employees have been in existence for many years (General Electric—Union College, Westinghouse—University of Pittsburgh, for example) and are now quite common (6). However,

Purdue University has established a unified M.S. program which will serve as a guide for off-campus programs (other examples of off-campus programs are Ohio State University, University of Maryland, University of California) as well as for a study of the unified curriculum concept (7).

Engineering as a Profession

More practicing engineers are now clearly concerned with the content, significance and responsibility of the profession (8) than was true in the past, however; see Waddell & Harrington in reference (9) for evidence of the activity and concern in the 'teens. Two events have contributed to this favorable climate. The present shortage of engineers has caused the professional engineers * to resurvey the position of the profession locally and nationally as he presents the facts to school counselors and to prospective engineering students.

Again the registration procedure in many States requires the evaluation of the professional experience of the candidate and the examination which is set is designed to evaluate the professional capabilities of the candidate. These forces require concentrated attention to the question of the status of the profession.

Thus the ethical, aesthetic, cultural, economic and technical content of engineering is evolving and the methodology implicit in the practice of the profession is slowly emerging.

Increased professional consciousness will reflect itself in the curricula. With time there will be greater emphasis on Engineering in contrast with emphasis on a specialty or branch. This changed attitude is and will be revealed in the philosophy of engineering instruction. The greater appreciation of the unity of knowledge (10) will influence both the profession and the curricula. For instance, systems analysis (or systems engineering or operations analysis) will become an essential portion of the climactic segment of the curriculum. Less attention will be paid to individual courses, their number will be reduced (22, p. 14), but more attention will be given to the thoroughness and content of individual courses and their articulation with other courses. The academic experiences of the student will be planned and executed as a part of an activity beginning in the 8th (or 9th) grades and extending to achievement of professional status some fifteen years later. This period will include the high school years, the four year engineering curriculum and industrial experience; between the undergraduate curriculum and the beginning of the industrial employment certain individuals may also include graduate work.

Technical Institutes

In the organization of an Engineering Department in industry, a variety of talents and training is needed. The profession will in the future vigorously support the development of training programs for those groups which form a part of the organizational structure of the professional engineer. Other professional groups have and are taking leadership in assuming responsibility for the training of contributing groups.

If properly organized the leadership of the Engineering Department in an industrial unit should reside in a professional engineer. A fraction of the group will be professional engineers, another segment will be engineers-in-training. But still another segment consists of those who have completed a two-year program (Technical Institute type) or equivalent (1, Vol. II, p. 11 and (11)). Some years ago many four-year engineering students withdrew during the first two or three years of a college curriculum. Was this abbreviated experience the optimum desirable for the semi-professional? Is there not a better way of training these young men?

Technical Institute type programs have been introduced in many sections of the country as an answer to the above ques-

* The excellent work of ECPD, EJC, ASEE, and Local Engineering Councils is noted.

tion, for instance, by Pennsylvania State College, Purdue University, in the junior colleges of California, in New York State, and in private, including proprietary, schools. Broadly speaking, the courses of these programs should not rest on formal physics and chemistry and mathematics courses beyond high school. Physical systems are described verbally and numerically. Numerical methods of analysis are used. Students learn about particular systems. Physical and chemical principles are taught and illustrated in connection with the system or apparatus under consideration. Arithmetic methods are introduced as needed. Verbal description and analysis replace symbolic description and analysis, the former augmented through pictorial means (drawings and sketches). Activities ancillary to engineering such as time-keeping, scheduling, etc., as related to the system or apparatus or job, are taught in terms of the system under consideration.

Pre-engineering courses do not suffice for this program. Imaginative guidance is needed and can be contributed by professional engineers, educators and teachers.

A four-year program including the equivalent of two years of general education (humanities, economics, accounting, language, literature, history) and two years of technical institute work as described above and closely integrated will fulfill a need for a man with a college training who will work with and assist the professional engineer.

Alternatively a four-year program including general education courses and certain of the science and applied science courses (partially equivalent to but not identical with engineering science courses) deserves consideration as a training regime for others who will work with and aid the professional engineer or who intend to enter engineering curricula for further study.

Flow of Information

As an educational center the engineering college is a component in a flow circuit. Knowledge flows outward through the undergraduate student, the graduate student, faculty consultation, faculty texts, and technical publications. The channels consisting of the newspaper, house organ, radio and television have not been exploited adequately. However, within the next generation the professional engineer will utilize more effectively these media of communication.

But the return flow path from industry and from the field to the engineering school has not been established as a conscious effort. Catalogs, advertisements, house organs, sectioned and working models, often available to the faculty and student, serve as a partial return path only.

A function of industry is to utilize knowledge, which process will generate further knowledge; in sum, the function of utilization results in the generation and diffusion and differentiation of knowledge. This information must flow back to the college where it should be formulated, integrated and generalized. Still further fragmentation of knowledge by the engineering college will be considered indefensible (10, 22, p. 37). Herein lies a research task, appealing to the imaginative instructor, which the engineering school will accept in parallel with the projects now in being (12).

A word will be included relative to the recording of engineering works. The product is the final record of an engineering design. Buildings, bridges, television sets, gas turbines contemporaneously exemplify the application of the engineering methodology to the satisfaction of the needs of man. But the idea upon being reduced to practice has also been committed to paper through drawings, designs, specifications, etc. A record of these engineering works may reach engineering publications and textbooks in part and very late. The time lag between discoveries and their general use can and will be reduced by increasing the breadth and effectiveness of repositories of engineering knowledge and the assumption by the engineering college of a new role in the

return path in the flow circuit of engineering knowledge.

Industrial Functions

Industrial functions (13) of import to the engineer often cited are design, research, development, production, construction, sales, service, maintenance and others. But these functions have not yet been carefully defined. For instance, what are the disciplines of the design function? Does a universal design methodology exist? The attention of professional engineers and of teachers will be directed to the problem of establishing the meaning of the design function and to develop its methodology.

Again the existing experimental data will be sifted and further data will be gathered in order that the production (14) and construction functions (and others) may be placed upon an analytical basis. Herein lies one of the greatest challenges to Engineering Educators.

The Curriculum

In this "outlook" little will be said about the undergraduate curriculum. Some of the elements of a curriculum are presented in references (15) (16) (17) (18) (19, Appendix VI) (20). Considerable thought has resulted in a tentative formulation of the content of the engineering curriculum, of engineering methodology and of the disciplines underlying engineering (18 and 24). Place has been found in modern curricula for the presentation of the analytical plus the experimental modes of solution and for the science as well as for the art of engineering.

A clarion call for the return of certain social-humanistic studies to the engineering curriculum (24) and their recognition as a stem paralleling the technical stem has refocussed attention on the trend toward the specialization (in this case the exclusion of non-technical engineering courses) which appears to be part and parcel of the "natural" evolution of curricula in the modern American college.

The effect of specialization and fragmentation of knowledge, a resultant of scholarship devoted to the rational extension of knowledge, upon courses, curricula, and instructor attitudes has been examined within the last two years with the conclusion that both general education and the discipline of synthesis (building or assembling in contrast with analysis) suffer in present curricular arrangements and teaching methods (21).

The social-humanistic content of the engineering curriculum will find its expression as an integral part of the totality of student experiences rather than in separate compartments or courses. The process of integration of Engineering, discovering the disciplines of the several branches, and establishing those disciplines which are common to Engineering will also automatically include the requisite elements of knowledge referred to as the social-humanistic (25). One of the great unifying forces in engineering education will prove to be a rational inclusive treatment of the properties of materials; the proper use of materials is the cornerstone of engineering practice. On the other hand, that segment of the student's education designed to equip him to meet the social and intellectual requirements of society (above and beyond his professional competence) will serve as another unifying force.

General Education

The goals of a total education have been listed by Day (26) as (A) to arouse interests, (B) to develop skills, (C) to convey knowledge, (D) to establish the import of understanding and appreciation, (E) to establish attitudes and ideals, and (F) to cultivate habits. The portion of the total education (consisting of the effect of the environment on man and his reaction) which may be considered as general education is defined by Hook (21, p. 311) as "the study of certain essential areas of knowledge together with the acquisition of certain basic skills which should be required of all students. These requirements should meet the needs of all human beings both as participating mem-

bers of the community and as individuals who must undergo basic life experiences, irrespective of their future vocation."

The portion of total education and general education which is now included in each 4 year engineering curriculum will need to be established explicitly. Total and general education goals will be formulated. The social-humanistic content of the curriculum will thus acquire more meaning and greater significance. The way is being illuminated by several colleges in the United States, such as, for example, the Carnegie Institute of Technology (15). The Engineers Council for Professional Development has progressed in this area and will continue its excellent work in cooperation with professional education groups.

Teaching

Methods of instruction and teaching techniques (19, 23) are receiving much attention, especially through the support of the American Society for Engineering Education. The introduction of the summer school for engineering teachers (1, Vol. II) was a great step forward but a return to the conception of breadth, rather than attention to detail, will characterize future activities of this type. The new vehicles of communication (recordings, films, radio, television) will each be tried and tested by engineering teachers during the coming years. The application of the experimental results obtained through a study of the several methods and techniques will represent a milestone in pedagogy.

Summary

In summary, the curriculum will be based upon principles of transfer of knowledge and of skills, upon the inculcation of a consciously formulated methodology, utilizing examples for incentive, continuity, and temporal pertinence, resting the illustrations upon natural (physical and life) phenomena, but with primary emphasis upon the phenomena themselves and their analytic formulation. Throughout the engineering educational process the complete growth of the student will be facilitated with the teacher as central (23). He will be encouraged to "know himself," to know others (and society), and to be a living example of the interrelationship between the physical and human worlds. For the student there cannot exist two stems (technical and social-humanistic) but rather a synthesis not only of the knowledge of the physical world but of knowledge itself (22, p. 58). In particular he will be given the opportunity to express himself orally (added to the present emphasis on written expression) and to give vent to creativeness—in other words, to "be himself." The student will feel that he is responding to an exciting stimulating experience which has great human implications and effects.

The author trusts that this "outlook" will contain both bases for action and stimuli for discussion. For only from free untrammelled unprejudiced rational discussion will the truth emerge. Each engineering school must find its own solution of the engineering student–faculty–industry relationship within a generally understood and agreed-upon framework.

Definitions

1. Engineering as an Art. In the application of ideal systems to the world-in-being many force fields are effective which are either unknown, cannot be analyzed, or, it may well prove, that analysis is too expensive. The knowledge of the professional engineer, based on scientific training but amplified by practical experience, fills the gap between the results of analysis and the behavior of the actual system. Often he does not employ mathematics beyond arithmetic as a language, his modes of expression being the native tongue and graphics (drawing), and his discipline is formal logic. He senses the magnitudes of variables which can neither be formulated nor evaluated by the scientist. Extrapolation from system to system with reasonable assurance of acceptable results with the details unknown is indeed hazardous; the exercise of this procedure accounts for the stature of the profes-

sional engineer. Briefly, he deals with a mass of unformulated knowledge.

2. Training is defined as the acquisition of knowledge and skills which are to be utilized in the solution of a particular problem or to be directed toward a particular end.

3. Education will be defined as the acquisition of knowledge and skills which are to be utilized to solve general problems or a range of problems such as are faced throughout a "full" life.

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Sections and Branches

The **National Capitol Area Section** held its Fall Meeting, October 6, 1952, at Catholic University of America, Washington, D. C. Vice-President Boring's letter was read concerning the best-paper competition for younger members of the Society, and the method was described for conducting the competition within the Section.

Chairman L. K. Downing then introduced H. H. Armsby, the Section's representative on General Council, who reported on actions taken by Council at the Dartmouth Annual Meeting. Mr. Armsby also reported interestingly on the Centennial of Engineering in Chicago. Following introduction of M. S. Ojalvo, chairman of the Section's subcommittee of ASEE Young Engineering Teachers Committee, S. P. Schlesinger, former chairman of that subcommittee, stated objectives of the committee and reported on its recent activities. Recent Development in the International Field was the subject of an interesting talk by S. S. Steinberg, chairman of the International Relations Committee.

Chairman Downing stated the theme for the Section's 1952–53 meetings,—Improved Utilization of Engineering Manpower,—and introduced R. L. Goetzenberger who dealt with the following questions: "What are employers doing to make the most effective use of present short supply of engineering manpower? Are the engineering schools doing all they should to aid?" His talk stimulated a lively discussion.

Looking Ahead in Engineering Education

By S. C. HOLLISTER

Dean of Engineering, Cornell University

During the past eighty years *we have witnessed a change in this country from an essentially agrarian nation to one of industrial power.* It has come about chiefly through the introduction and utilization of technology. This basic change has had a profound effect upon the country's international position and upon its potentiality for moral and spiritual, as well as economic, leadership.

During the past fifty years the population of the country has doubled. Our production, however, has increased to four and three-quarters times what it was at the turn of the century. This has come about largely because we have been able to develop and apply, at the hand of the worker, about four and one-half times as much energy as was available to him in 1900.

Not only has the engineer made possible this increase in production; he has had profound influence upon transportation and communication as well. The world has shrunk in size in terms of the movement of goods and people. Every part of the world now may listen to every other part so that all may know the doings of any people as they occur.

Some of the earlier steps in our industrial development could be achieved with little more than native ingenuity. However, the introduction of engineering education in the country became increasingly effective; until now it is a necessity, both for the maintenance and the advancement of the technological system.

Since preparation by way of education always precedes the accomplishment, it follows that *the planning of engineering education requires an estimation of the future and its needs.* Today we are laying the groundwork for the accomplishments of twenty-five years hence. A look ahead, therefore, into the world of a quarter of century from now should furnish us some guiding principles upon which the future trends of engineering education should rest.

It is the engineer's lot to be called into situations in which there are serious problems. There are many serious problems confronting this country; solutions of which will have to be found in the relatively near future. Such problems tax the ingenuity and capacity of our profession.

A whole group of problems arises from economic sources. America has always plunged into full use of its natural resources with very little thought of what might occur after the sources have been exhausted. We have been depleting them at a terrific rate. We have said to ourselves that when these resources are gone others will surely be found to take their place. How these were to be found was left largely to yankee ingenuity and technical know-how. In many spots the time has now come when we must get busy developing the know-how to meet some of these basic problems.

From one source we learn that for every barrel of petroleum taken out of the ground two more barrels of petroleum have been found that were not known about before. From this it has been concluded that we have an inexhaustible supply of petroleum. All we have to do is to develop new means of detecting the petroleum that is not at present known about, and new means of producing and refining petroleum that is known about but is in such form that at least a considerable portion cannot readily be extracted by known

means at a reasonable economic cost. While some say we have an inexhaustible supply of petroleum we have, during the past decade, changed from an exporting to an importing country so far as this particular material is concerned. During that decade we have also turned the same corner with lumber, and the decade prior to the last, we turned the corner with zinc and copper. We are about to become a large importer of high-grade iron ore. Of course, tin, nickel, natural rubber, chromium, and most of our manganese have had to come from the outside, along with some of the lesser quantities of economically strategic materials.

It is expected that our population in the next twenty-five years will increase by twenty per cent. This will affect what is needed to maintain the basic economy at a reasonable level. We will in addition have continuing commitments abroad which must also be cared for, where in many places rising populations menace the economic balance.

In agriculture it is expected that the yield per acre by 1975 will have had to be increased over forty per cent. Some of this of course will have to come about by further engineering developments and some by new conceptions, new discoveries and new controls in plant science. The result in production, however, is that the number of people fed per farm worker must be increased in twenty-five years by forty per cent.

It is no news to people in many parts of the country that one of the critical materials now in short supply is water—water for irrigation, water for industrial uses, water for drinking purposes, water for navigation. Although the country has an enormous supply of water, it frequently is in the wrong place or occurs in the wrong season. Immense problems lie ahead in *meeting the water situation so that there may be redistribution, reclaiming of used water, and conversion of sea water into potable supply.* Unless any of this can be done at an economical cost, it is of course of no avail.

Another problem that faces the country is *the development of a sound policy and practice respecting our timber resources.* This has been a subject of active discussion for at least fifty years, but the problem is still with us and the engineer faces the need of further development for economical use of wood products, or an adequate substitute for a fair amount of the present supply.

We appear to have a very large supply of *coal.* One of the problems of this supply, however, is not whether there is ample quantity of coal of good quality, *but how it may be wrested from its present natural site and supplied at the point where it can be used effectively.* Possible conversion in the natural site to another form, such as gas, which may be removed and transported more easily than the original solid coal, is one possibility that has been worked upon to some extent. The amount of coal needed twenty-five years from now may conceivably be one hundred per cent in excess of the present production. It must be recalled that one means of covering the shortage of petroleum is by the synthetic manufacture of petroleum products from coal. It must also be recalled that petroleum is a raw product for the development of many chemicals; a use which is rapidly accelerating. This use is an addition to that of petroleum as fuel, and may eventually form a major portion of the demand upon coal, if the raw source is transferred to that material.

Another natural resource which is being consumed at a terrific rate is *natural gas.* The use of this fuel has increased threefold in the last fifteen years. Like petroleum, this form of fuel is being used extensively for fuel in its crude form. The day may not be far distant when the need of special products made from distillation will become critical. At such time we may regret the inefficient use of the material in its crude form, and its depletion to the point where the supply is below the required need in more effective form.

To a constantly increasing degree we are *utilizing electrical energy* in order to multiply the effectiveness of a man-hour of work. Most of our electrical energy is

available to us through the development of thermal power. Although some hydroelectric power may still be developed in the future, it will not form even one-quarter of the total source of electrical energy that will be needed in another twenty-five years. This is another way of saying that the major power expansion of the future will be through the development of further thermal power with its consequent demand upon coal, natural gas, and petroleum.

Whether in the field of materials or in the field of fuels, the ultimate goal is constantly to work toward the harnessing or utilization of supplies or materials or energy that are well nigh inexhaustible. For example, many products that are now waste might conceivably be converted into useful substances. Solar energy which is in some parts of the country in abundance around the calendar might some day be the source of energy that now depends upon the consumption of some of our priceless natural resources. The constant struggle towards this ultimate goal is a struggle which will set more and more men free throughout the world. The more general the occurrence of the base of our source of materials or power the more free will mankind become.

Thus far I have discussed largely the consequences of the need of our expanding economy because of the expansion in our population. There are other factors which place great burdens upon the engineering profession. Consider for a moment a continuing interational situation which maintains a high tax burden upon the citizens of the country. The tax burden, it is generally agreed, is about as high as it can well be short of all-out war. Put in another way, it means that each man has just about reached the saturation point of his buying power, because of the tax burden. If wages and prices go up together this of course does not increase the buying power, except during the transition stage. We cannot afford always to be in that transition stage. *The problem therefore is what we can do to give people greater services for the same amount of money.*

There are a great many things that need redesign in the interest of saving money. As an example, it is extremely difficult today for a young man, regardless of the field in which he is working, to acquire a home and a young family at the same time. The cost of present-day construction is forcing more and more people to undertake building their homes with their own hands. This is one form of answer to labor organizations that undertake to put artificial barriers in the way of necessities by actually demanding pay for no work. The economy in the past has supported a certain amount of boondoggling, but there is a limit to what people will stand after which checks and balances are developed by the consumer.

But housing is only one form of commodity, the cost of which is too high. Other appliances must be redesigned in order to be considerably simplified and reduced in cost. This would give an opportunity for the purchase of some other appliance that now cannot be afforded. For example, our automobiles are too highly priced. *We badly need a cheap car,* one that will furnish transportation with comfort but not luxury. We need cheaper radios, television sets, refrigerators, air-conditioners, washing machines and the like. In time they may come, but we need these things now.

The American people have learned to do many things the expensive way. We are going to have to learn to keep things simpler and still perform the essential functions. This calls for the highest form of skill in design of which the engineer may be capable. It is our present tendency to add gadgets on top of gadgets to the point where sheer accumulation is burdensome. *We need to learn how to live more simply, and as engineers we need to learn how to design more simply, so that we may have more.*

In no part of our present economy is it more essential that simplification be practiced than in the conduct of war. In a continuing emergency we have no place for the old theories of war which held that costs of materiel were no object so long as

we won the war. What we must now do is to conserve our resources and still be in the position to win a war. In fact, unless we do conserve our resources we may not win out, either in war or in peace.

There is still another area in which the state of our economy suggests much work for the engineer. With continually increasing mechanization we create more wealth with fewer actual man-hours of labor. Obviously this would bring about unemployment if it were not for the fact that new products may be made with the labor saved in the first operation. The result, heretofore, has been a continually expanding industrial organization.

Whether this can go on *ad infinitum* has not yet been ascertained in the world. Whether the system can be applied to countries which have a greater population per unit of area than we have has likewise not been determined. The engineer is being called upon to work out these theories, both at home and abroad, especially in countries with less fortunate living conditions than our own.

Without considering the pressures upon our economy developed through the need of support from us to other nations, or the need of continued military preparedness, it is already clear that the engineering problems that are piling up ahead of the profession are accumulating at a rate far greater than the rate of increase of population. In fact, the problems are appearing at a constantly increasing rate, and there is no end in sight.

I have reported in other places that we have now reached the point in the development of engineers where we may expect no percentage increase of engineers in terms of the total population. We thus find ourselves leveling off in terms of numbers of engineers as per cent of population, whereas the really tough problems accumulating before the profession are piling up at a rate far greater than the rate of population growth. This is another way of illustrating the point that *engineering services to the community at large are increasing per engineer available for such service.*

What effect has all of this upon engineering education? We may ask ourselves what it is we are now putting into the hands and heads of our students that will really be effective in dealing with the kind of problems that we have laid out before us. How have we strengthened the scientific and technical preparation which we are now asking our students to master?

It is very clear that we cannot delineate sharply the various techniques that will be in use twenty-five years or fifty years from now; but it is certain that the principles on which these technical developments will be based are principles which are now available in the basic sciences. *Our problem, then, is to strengthen the basic science content of our curricula.* The importance of this conclusion is emphasized when it is recalled that the problems now before us are tougher to solve than the problems that have been before us heretofore, and require a more fundamental approach.

Another approach to the total problem of engineering manpower is the realization that with the requirement of increased effectiveness of each engineer there must be a readjustment in order to reinforce the work of each engineer. *This calls for a supply of capable engineering aides.* The training of these technical aides in itself should be advanced beyond what has been in use in the past. *This suggests the possibility of modifying our educational system to provide for the development of the professional engineer at a higher level than heretofore, together with the development of technical aides also at a higher level of training than is at present customary.* It may well be that the pattern of professional schools in the future will involve a more extended program than we now have, supported by four-year programs which will be calculated to develop the sub-professional personnel. It is conceivable that all of these programs would be collegiate degree-granting programs but of different duration and resulting in different degrees. I am not at the moment dealing with graduate study as such, but

I am dealing with education of the great majority of engineers who will go out into practice in the profession.

It is obvious that we are looking toward a period in which the function of the engineer is going to be increasingly important in the area of economic and political affairs, as well as in technical progress. In the planning of our education of engineers we are not permitted to reduce the little time that is now being spent in *broadening the professional engineer's background of knowledge.* On the contrary, *it is essential that we extend this time to provide a richer education than we can at present give him.*

In all of the foregoing we see the great need for expanding our creative activities. Recently I read an article in which one of our leading industrialists argued that our natural resources were inexhaustible. He cited cases in which there was a present knowledge of large deposits and the hope that many more deposits could be added to these if we could improve our methods of exploration, discovery, extraction and processing. If we could do all these things then our natural resources would be inexhaustible. Apparently he did not readily recognize that the inexhaustibility that he was depending upon was largely the inexhaustible ingenuity of engineers.

It is this inexhaustibility of engineering resource that concerns us in engineering education. We as educators must address ourselves more assiduously to the *task of developing in our students their imaginative, creative ability to a higher level than we have achieved in the past.* In fact, much of our teaching methods have not been aimed at this objective.

I do not want to be interpreted as believing that imagination can be put, by teaching processes, into the head of someone who has no imaginative power. I do firmly believe, however, that imaginative, creative ability may be enhanced by teaching methods. I am sure also that in the world today and in the engineering profession creative talent is the greatest needed and the most highly prized.

Whether the engineering educators accomplish the goal of service to our profession in the form here suggested is not important. What *is* important, however, is that we address ourselves vigorously to the task of appraisal of the situation, and then of arriving at an adequate, equitable and effective program.

Sections and Branches

The fourteenth annual meeting of the **North Midwest Section** of ASEE was held October 3 and 4 at Iowa State College. The main event of the meeting was the Annual Dinner which was high-lighted by an address by Leonard J. Fletcher, Vice-President and Director of Community Relations, Caterpillar Tractor Company. He spoke on "The Answer Not Found in Books." The meeting was closed with a luncheon where the annual business meeting was held and L. O. Stewart, former Council Representative, reported to the section on "Society Affairs."

For the technical sessions two general and six departmental meetings were held. The topics for the general sessions were: "An Experiment in Education-Television"; and "Humanities for Engineering Students."

The next meeting of the Section is to be at Milwaukee, Wisconsin on October 9 and 10, 1953, with Marquette University as the host institution. Elected to serve as officers for the next year are: Chairman: A. B. Drought; Vice-Chairman: Chester Pratt; R. J. Panlener: Secretary-Treasurer; Council Representative: K. F. Wendt.

Since engineering is changing from an art to a science, it is natural that more engineers are called upon to assume the role of the scientist and to advance the frontiers of knowledge as well as to use that knowledge for the benefit of mankind. If this is true, then he should be educated as a scientist.

The following three papers were presented at the ECRC (ASEE) Centennial Conference under the Chairmanship of Eric Walker, Vice President of ASEE and Dean of Engineering, Pennsylvania State College, September 5, 1952. Dr. Furnas, in the first paper, extends the thesis that many of our engineers are indeed scientists and Dr. Ihrig shows how education in industry should be bent to this aim. Dr. Brown advances new ideas concerning the role of education in our colleges.

The Engineer-Scientist of Today by C. C. Furnas

The Modern Engineer Should be Educated as a Scientist

In Industry: by Harry K. Ihrig

In College: by Gordon Brown

The Engineer-Scientist of Today*

By C. C. FURNAS

Director, Cornell Aeronautical Laboratory, Buffalo, N. Y.

From testimony in various quarters and from observation, it would appear that the ideal engineer should be a handsome and well-groomed biological specimen, with costume and coiffure readily changeable at will, and on short notice, to fit the traditional appearance and characteristics of: a research scientist, a plant operator, a professional designer, a technical detective, a salesman, a plumber, a leader of field parties, a leader in public affairs, a sociologist, and a business man. It's quite an order.

In the simpler days when things could be readily categorized, the relations between character of knowledge required and activities pursued might have been summarized in some such fashion as:

The Skilled Craftsman specialized in "know how."

The Engineer dealt primarily in "know what."

The Scientist lived in the domain of "know why."

Now it seems that the engineer is expected not only to know "how," "what," and "why." For reasons of sociology and salesmanship, he is also expected to "know who." Truly he is to be all things to all people and the educational system is subject to criticism because it doesn't continuously turn out the desired, universally adaptable, marvelous product.

Even if someone did exist who knew all the answers to the problems generated by this multi-headed demand, he could hardly cover the field adequately in any finite period of time. Fortunately, however, the director of this symposium has simplified matters by ruling that the discussion shall be limited to the general theme: The Modern Engineer is a Scientist. This markedly narrows the field and promotes simplification, but even this restricted subject is tremendously complex and probably no one (certainly not this speaker) knows any of the exact answers to the problems. But I shall attempt to make a few observations, for whatever they may be worth, within the frame of reference of the engineer as a scientist. Be it known, however, that I am not one who believes that all engineers should be in the "scientist" category, any more than that all physicians should be research experts. In all the professions there is a real necessity for a large proportion to be the more prosaic practitioners, and education and training is short-sighted which neglects this need.

Before proceeding with the discussion of the specific problem in hand, a brief survey of the make-up of the engineering profession is in order. At the present time there are about 400,000 engineers in the country with employment distribution roughly as follows: universities 9%; government 24%; industry 67% (reference—*Bureau of Labor Statistics Bulletin No. 968,* May 1949). Depending substantially on definition, somewhere between three-fourths and seven-eighths of all those who have received engineering education remain within the confines of the profession, if you include administrative and executive posts which are closely linked to technical organizations. (With a more strict definition of engi-

* Talk delivered at meeting of the Engineering College Research Council, Chicago, September 5, 1952.

neers, others have estimated that approximately 50% stay within the profession.) At the present time roughly 15% of all engineers are engaged in research and development (reference—Furnas, *Jour. Am. Soc. Eng. Ed.*, Sept. 1952 p. 24) and this category embraces the bulk of those who fall in the "scientist" type of activity.

In addition to the engineers who at any one time have the strong scientist tinge, there will probably be a number who are on their way up from the ranks. So, as a liberal estimate, some 25% of the individuals in the engineering profession are, or will be, those for which extensive, effective and profound scientific knowledge and understanding is a necessity. A most important and necessary 25% it is, but in considering education and training let us not fall into the dangerous error of producing all Chiefs and no Indians.

Focussing attention on the select 25% (those in research, development, and new, constructive design) we find that there are some real problems in keeping up with the game, and probably some serious defects in the educational system. The situation was probably best summarized yesterday by Dr. W. F. G. Swann, at another symposium of this Centennial, when he said "The time is coming when the engineer will find that the sharpening of his old tools is not sufficient for the task." It is a sage and worthy observation. The situation will bear careful analysis.

Trends in Engineering

At the risk of appearing to be in my dotage and perhaps of being guilty of erroneous conclusions, I would like to list some observations on the trend of affairs in the engineering activities associated with research, development and design over the past 25 years. These come from the vantage point of practice, teaching, and administration of research and development, and from exposure to two distinctly different fields: (a) chemical engineering, and (b) aeronautics:

(1) Practical engineering problems have steadily become larger, more complex and more sophisticated.

(2) There has been a progressive trend away from straight empiricism and toward designing exactly and with confidence. In the chemical industry, pilot plants are sometimes omitted and in the mechanical and electrical fields much of the inventing is done on the drawing board.

(3) The use of theoretical considerations has increased a great deal in approaching new problems. This has been especially marked since the rise of the computer art which makes it possible to arrive at solutions of a multitude of synthetic problems, quickly. Computers are also rapidly becoming a basic research tool for fundamental scientists.

(4) Despite the decay of empiricism, laboratories have greatly increased in number, size and scope. In the applied research and engineering fields they are largely used to: (a) get quantitative information for design purposes and (b) proof-test prototypes or components, and (c) work out final design improvements.

(5) The "team" approach to most engineering problems predominates, which tends to throw the very best engineers onto one side or the other of administrative problems, despite all efforts to avoid them.

Characteristics of Successful Engineers

Matched against the above list of changing characteristics of the task, I would like to record some observations of the characteristics of individuals who have proven successful in the fields and activities with which I have been in contact. Perhaps my sample is not sufficiently large to serve as a basis for generalizations, but it does involve close acquaintance with at least several hundred individuals. As I have observed them, the principal characteristics of the successful engineers, a la scientists, are:

(1) They have high IQ's.

(2) They apparently have had *good*

undergraduate scientific training, but no particular colleges or universities seem to dominate as alma maters.

(3) They appear to have true scientific understanding. They really grasp the implications of $F = ma$.

(4) They may come from any part of of the country. They can come from any part of the world, but usually the European-trained scientist or engineer is less adaptable than the American-trained one. This is independent of any language barriers.

(5) They have drive, imagination and tenacity and at least reasonable judgment. They are not always, however, eager beavers or highly energetic people. Some are very leisurely and a few even appear, superficially, to be lazy.

(6) In the applied research and development activities those with engineering schooling appear to be in the majority but there are many with training as physicists, chemists, and mathematicians. This seems to come about as a result of the team approach to problems.

(7) Though there is a larger proportion of graduate degrees than in the routine phases of engineering, graduate degrees appear to be no requisite for success. A Ph.D. degree seems to help but it is no guarantee of success and no safeguard against sterility.

(8) More often than not they are poor salesmen and somewhat less than social successes. Whether they succeed in spite of or because of this, I am not prepared to guess.

(9) The most outstanding and most important characteristic in common is that they are *always acquiring* or *developing* new mental tools, by self study, improvising new tricks of scientific approach, exchanges of ideas with colleagues, or by formal course work.

As an appendix to these observations, it should be noted that many engineers and scientists get into and prove very effective in administrative and executive positions without having had any outstanding accomplishments as scientists or engineers. The brain trust boys—particularly the asocial ones—frequently bridle and grumble at this, but it goes on happening just the same.

What do the members of the polyglot collection of scientific engineers do which distinguishes them from the garden variety of engineers on the one hand and from the true scientists on the other? The principal and unique characteristics of their activities would appear to be two:

(1) They deal with items that are new, as distinct from minor modifications of already existing devices, processes or systems. This removes them from the routine engineering categories.

(2) Their objective is not to acquire knowledge for knowledge's sake (however interesting and intriguing that may be) but to produce some thing new, useful and usable. This sets their activity outside the pale of "pure" science tradition. Scientific knowledge is the most essential tool of their operation, but not the end object.

Examples

Examples of the work of the sophisticated school of engineering are easy to find. They involve the work of many people of many interests and background, but they all call for the skilled mind of the engineer (whatever may have been his academic background) who knows and uses new scientific tools within the frame of reference of engineering application. Some of the examples to be cited represent past or very recent successes. Others are items that are still "in work" and practical success is not yet assured. A few samples:

(1) Chemical Syntheses
   (a) The development and use of nylon—probably the top example of a truly new, entirely synthetic, specific material for mass use
   (b) The large series of aromatic compounds from the straight

chain, or aliphatic, materials of petroleum recently announced by the Carbide and Carbon Chemical Corporation

(2) Pharmaceuticals
  (a) The mass production of penicillin and other mold-generated specifics
  (b) The semi-synthesis and production of cortisone

(3) Electronic Devices
  (a) Modern television
  (b) Radar
  (c) The proximity fuse

(4) Communications Systems
  (a) The coaxial cable
  (b) Ultra high-frequency radio

(5) Nucleonics
  (a) The atomic bomb
  (b) Production of tracer materials

(6) Power Devices
  (a) Atomic stationary power plants
  (b) Atomic propulsion of ships and aircraft
  (c) Jet propulsion and other applications of the gas turbine
  (d) Ram jet engines
  (e) Liquid rocket motors

(7) Control Systems
  (a) Automatic navigation and autopilot systems for aircraft
  (b) Guidance systems for guided missiles
  (c) Industrial power control systems
  (d) Automatic control systems for complicated chemical syntheses

(8) Metallurgy
  (a) The production and use of titanium and its alloys
  (b) The production and use of ceramels (combinations of ceramics and metals for high temperature work)

(9) Computers
  (a) As used in gunfire and guided missile control systems
  (b) As used in flight simulators to work out aircraft flight problems and for training

(10) Aeronautics
  (a) Development of successful helicopters
  (b) Development of supersonic airplanes and guided missiles

Anyone can quarrel with the incompleteness of the above list, but it is only intended to be a small sample. He can also quarrel with the classifications or groupings, but one of the characteristics of modern developments is that they refuse to be simple, or confine themselves to single, rigid categories. The primary characteristic of the above items is that, in no case, were (or are) the answers to the key problems to be found in then-existing hand books. Seldom were the complete answers to be found in even the latest literature of pure science. The marshalling and integration of all available knowledge was required and frequently the discovery of substantial blocks of new basic information was necessary. It is the engineer (whether his academic handle says he is one or not) who pushes these items through to successful conclusion. It is fairly evident he cannot escape being a good scientist, too.

Teamwork Necessary

The second major characteristic of all items in the list is that success of the project was dependent on the work and talents of many individuals. In no case in the list could the scientific and engineering man-power requirement for a particular project be numbered in less than hundreds. In most cases, thousands were necessary; hence, the inevitability of large teams, with their attendant administration problems, in modern engineering projects. So despite my best efforts to confine my observation to that type of engineer who must be a scientific individual, I find myself coming full circle and saying that this rare and valuable individual must still be imbedded in a complex sociological matrix.

We now come to the crux of the discussion—the question: So What? Though I will admit that it is highly unsports-

manshiplike, I'm going to renege on attempting to answer that, for the two speakers who follow have that pleasant task, as representatives of education and of industry. Before turning the matter over to them I would, however, like to point out two almost self-evident facts:

(1) The education of the engineer, a la scientist, must continue throughout his entire professional life.
(2) Both educational institutions and industry have, not only an interest, but a duty to perform, in this pattern of never-ending education.

College Notes

J. H. Potter of the **University of Illinois** and T. Stephen Crawford of the **University of Rhode Island** have been granted leaves of absence to participate in the E. I. du Pont de Nemours and Company program "A-Year-in-Industry" for engineering educators.

Joseph V. Foa, head of the Propulsion Branch of the Cornell Aeronautical Laboratory at Buffalo, has joined the faculty of **Rensselaer Polytechnic Institute.** He has been appointed a professor in the Department of Aeronautical Engineering and will do research and teaching in the theory and application of jet propulsion and combustion.

W. R. Van Voorhis of **Fenn College** has been appointed Visiting Professor of Engineering Administration at **Case Institute of Technology;** he is also a member of the Case Operations Research Group.

Two major grants amounting to $1,000,000 by The Ford Foundation to the **Massachusetts Institute of Technology** for the support of research in the newly established Center for International Studies have been announced by President James R. Killian, Jr.

Construction started on Nov. 17 on a new engineering building at the **University of Wichita.** The building, which will house offices, classrooms and drafting rooms for the school's five engineering departments, will be completed in time for use in the fall of 1953, according to present plans.

John M. Russ was appointed Head of the Department of Engineering Drawing at the **State University of Iowa,** replacing F. G. Higbee, who has retired. Higbee will continue to serve the University on a part-time basis. M. L. Betterley was appointed Associate Professor in the same department.

By action of the Board of Trustees, H. Russell Beatty has been named Acting Dean of **Pratt Institute's** School of Engineering, replacing Nelson S. Hibshman, who is resigning to accept the position of Assistant Secretary of the **American Institute of Electrical Engineers.**

The nations's first graduate School of Industrial Administration at **Carnegie Institute of Technology** was dedicated recently. The featured speaker at the formal dedication ceremonies was Sidney A. Swensrud of the Gulf Oil Corporation. Carnegie's graduate School of Industrial Administration, founded in 1949 by a six-million dollar gift from the W. L. and May T. Melon Foundation, aims to provide young men with potential for leadership, fundamental training in management and engineering, and in responsibility for citizenship.

The Modern Engineer Should be Educated as a Scientist. I. In Industry

By HARRY K. IHRIG

Vice President in Charge of Research, Allis-Chalmers Manufacturing Company

Introduction

In the last forty years industry has changed more perhaps than in the previous hundred years, yet it has been reported [1] that in most engineering colleges the curricula in at least civil, mechanical, mining and electrical power engineering have not changed materially in that time. Since engineers are trained primarily for industry, it would seem that with the revolutionary changes going on which make industrial processes more scientific and more highly technical, the engineering courses should have been changed to adapt them to industry's needs.

The census figures show that in 1900 one graduate engineer was hired for each 250 workmen in industry. In 1950 one graduate engineer was employed for each 52 workmen and industry was asking for many more.

Taggart in a recent article [2] has said "Engineering education today is like a crazy quilt of somber wools and gaudy shoddy, chain-stitched on an academic assembly line, and sold at ever mounting prices to inexperienced youths for lifetime use. Each engineering school offers a half-dozen or so patterns with essentially the same skimpy wool content. Sales appeal is in the color of the shoddy, denoted by the hopeful adjectives chemical, civil and the like. This article is argument for an all-wool product made by slow, careful handwork. Bluntly it proposes a thorough four-year undergraduate drill in fundamental science and general engineering empirics, leavened by continuing study of the third of the engineer's troubles: Man."

This discussion is limited to the technical portions of the engineer's training.

Preindustrial Training

Since industry has become so complex and because it is continually changing, it is imperative that the engineer be trained in the fundamentals of science rather than the specific "practical" courses of any one industry. In fact, industry today with its indoctrination courses will train engineers with the most modern equipment and pay them well while so doing. Isn't this preferable to the student to taking up time in the engineering school trying to learn such subjects on equipment that is often obsolete.

None of the thousands of engineers on atomic energy projects could possibly have had specific courses in this particular field. Yet many physicists, chemists and engineers were able to adapt their fundamental training to this entirely new field. The only way an engineer can adapt himself to the new things developed after he has finished his formal training is to have his training embrace enough fundamental science so that he is able to make new applications of that science whenever necessary.

[1] Thorndike Savilk, "Engineering Education in a Changing World," *Journal of the American Society of Engineering Education*, Vol. 41, p. 4, 1950–51.

[2] Arthur F. Taggert, "Education for Engineering," *Mining Engineering*, Vol. 4, No. 8, p. 770–774, August 1952.

Augustine B. Kelley in a recent article[3] shows that the engineer is essential in the highly mechanized coal industry in the United States. Because of its mechanization our coal industry produces about four times as much coal per man as the next best producer. Also in the utilization of coal in such applications as the coal burning gas turbine highly scientific engineers are necessary.

In the oil industry science is used from geophysical prospecting to the synthesis and rearrangement of hydrocarbons to obtain the maximum antiknock properties in gasolines. The recent development of petrochemicals has opened up a whole new field for the application of physics and chemistry in the engineering of these products.

Allis-Chalmers Manufacturing Company makes about 1600 different items from tractors to hydraulic turbines. No possible engineering course could cover the specific manufacture of half of these. Yet all of them are based fundamentally on physics and chemistry with mathematics as the shorthand for expressing chemical and physical facts.

Engineering Training in Industry

Industry has not assumed that the universities have trained engineers in its specialized procedures. But it would like to be able to assume that the engineer has had a broad fundamental training so that he can adapt himself to industry's special needs. To this end industry has set up various training methods. The larger companies have formal courses, and the smaller ones depend more on personal instruction by older engineers.

A well known example of training supported by industry is the Institute of Paper Chemistry at Appleton, Wisconsin. In addition to paper technology, science courses are given and graduate degrees are conferred. The graduates of this course have made very good records in the paper industry.

The Humble Oil and Refining Company has courses of graduate level given by outstanding engineers and scientists from universities, who are invited to participate in this program by giving lectures and seminars in their various specialties.

Courses in reactor technology are given engineers from industry at Oak Ridge. This training gives them the proper background for the design of equipment to be built by industry for the Atomic Energy Commission, and for the eventual use of atomic energy by private industry.

In many cities, universities give evening courses for engineers in industrial plants. For example in Milwaukee, the University of Wisconsin gives graduate courses in Mechanical, Chemical Metallurgical, and Electrical Engineering. Research work for the master's thesis is done in the plants where the engineers are employed. During the last acadmic year 170 graduate students were enrolled. The enrollment for graduate work leading to the master's degree has steadily increased.

The courses are taught by regular faculty men from the College of Engineering at Madison. The student registers in and receives his degree from the Graduate School of the University of Wisconsin exactly the same as if he were in residence there. This enables an engineer to work full time and obtain a master's degree in two or three years by taking his graduate courses in the evening and doing his research work in the Company's laboratories or plants.

A University Cooperating Committee of the Wisconsin Society of Professional Engineers composed of engineers from industry has studied many of the engineer's problems. The writer has been a member of this committee for a number of years.

The Technical Institute was studied to determine its place in the educational and industrial engineering fields. It was recommended that the Technical Institutes be encouraged to train men for specific jobs to aid engineers in industry. This

[3] Augustine B. Kelley "The Engineer—Key to Coal Progress," *American Engineer*, p. 7–10, August 1952.

training should be given in technical institutes not directly connected with the University. The courses should be specialized and terminal in nature and should not be accepted for credit in the engineering college of the University. The function of the technical institute graduate is to do what might be termed sub-engineering jobs so that engineers may be used only for professional work. One of the best ways to alleviate the shortage of engineers is to use them for only truly engineering functions in industry. The technical institute graduate can thus release engineers for the real work for which they have been trained.

The medical profession for many years has used nurses, X-ray technicians, therapists, and other sub-professional help to aid the physician and hence free him to direct the medical program.

The University Cooperating Committee next studied a course in fundamentals for non-specialized engineering training and it was decided that such a course was very desirable from the industrial standpoint. A course was recommended which would consist approximately of:

Mathematics	28 credits
Chemistry	26 credits
Physics	33 credits
Engineering Fundamentals	33 credits
Humanities	24 credits
Total	144 credits

This would be a four year course with a preponderance of science and would lead to a degree of Bachelor of Science in Engineering. Specialization would be left for graduate studies.

Thus a committee of representative engineers of long experience in industry has indicated that there is a need for engineers trained in fundamental science, and that these engineers can be released for such fundamental work by providing Technical Institute graduates to do sub-professional work.

It is often said that fundamental courses are all right for large companies that have training programs, but that small companies require engineers trained in specialties so that they can start work at once. One of the members of this committee is a mechanical engineer who owns a small company manufacturing mechanical equipment. He believes that a broad fundamental training is very important in a small company where the engineers have to be versatile because the company cannot afford an engineer for each specialty.

Allis-Chalmers has had a training program for many years for graduate engineers. This training costs the company about $10,000 per year per man. It consists of lectures and on the job training in various departments. The same training is given to all engineers regardless of specialty. In the recruiting of engineering graduates no specialized training is required of these graduates. A sound background of good scholarship in fundamental subjects is one of the principal standards for picking the man.

In addition to the practical training given in the Allis-Chalmer's plants, courses also are given in graduate engineering subjects by members of the faculty of the Illinois Institute of Technology. These courses may be used for a Master's Degree. The instructors come to the plant to give the courses in the evening. The Company pays a third of the engineers' tuition upon registration for a course and another third upon satisfactory completion of the course. A number of men obtain advanced degrees in engineering each year in this way or through the University of Wisconsin's graduate courses given in Milwaukee. Research work for the thesis may be some problem that is being worked on for the company on company time or it may be a problem of no direct interest to the company. In the latter case the work is usually done on the student's time, but with company equipment in the plant.

Value of Fundamental Scientific Training in Industry

Engineers usually enter one of four major fields in industry:

1. Design.
2. Production.
3. Sales.
4. Research and Development.

Scientific training is valuable for design because it provides the basis for the creative work necessary. It gives the design engineer the background that enables him to design machines and processes that will work commercially, and that will not violate some fundamental laws. Design is similar to research in that it requires imagination and an ability to visualize new equipment and processes and also new uses for old equipment. A sound background of science is necessary to enable the design engineer to read its literature and hence utilize all new discoveries to produce modern equipment.

Engineers employed in production in today's intricate manufacturing must be well schooled in science because production is no longer an application of brute strength to the fabrication or processing of materials; it is no longer a "cut and try" procedure; nor is it a sterile following of conventional patterns which have proved successful in the past. But rather it is an application of scientific principles to operations to give maximum efficiencies. Often production engineers are able to make improvements in processing that eliminate much expensive labor. Since modern production equipment is highly scientific, an engineer who operates and maintains this equipment also must know his science. Quality control by statistical analysis is an example of the use of science in manufacturing. Machining also has been improved as the result of scientific studies on metal removal.

Sales engineering is a field with increasing interest to engineers. Although this field is often entered by many without engineering training, nevertheless sales engineering is a real profession and requires scientific knowledge. The products of highly scientific design and manufacture can be sold only if they fit into the customer's plants and processes. A wide variety of conditions and needs are encountered by the sales engineer. He must be able to discuss each customer's technical problems with engineers in that business. It would be impossible to train engineers in such a wide variety of technologies, but a basic training in science allows the sales engineer to quickly understand and adapt himself to any of the special conditions he meets.

In research and development, it is usually conceded that a thorough knowledge of science is essential. Here on the frontiers of knowledge, only the guideposts of the fundamental sciences can be used as the take off for expeditions into the unknown. There is no dividing line between the scientist and engineer in research and development. The data obtained in this field are necessary for use by the design engineer to enable him to design large scale equipment and processes. The future of all manufacturing and engineering is determined by research. Only by having a thorough knowledge of science can an engineer progress in research, and to get this knowledge graduate training is desirable.

About half the engineering students do not practice engineering as a life work. They may go into patent law, purchasing, construction, or any business function. Can these engineers profit by scientific training? I think they can. Science is simply common sense or logic applied to natural phenomena. The scientist gets the facts and weighs the importance of each before coming to a decision. This is good training for almost any life career. It is much better than specialized engineering training for which these engineers will never have any use.

Industrial Needs for Scientifically Trained Engineers

Industry requires engineers who have had four years of study in the fundamental sciences such as physics, chemistry, mathematics, thermodynamics, electricity and mechanics. Such graduates in non-specialized engineering should then

enter industries' training programs or should take graduate work in the universities for advanced degrees.

These engineers should be used for professional duties in industry with Technical Institute graduates and other technician's help to assure maximum utilization of limited numbers of basically trained engineers. Such education and utilization of engineers will raise the standards of engineers and assure industry of an ample supply of adequately trained men.

There is not complete agreement in academic circles on the advisability of fundamental training of engineers and their graduation without designation. Therefore, it is suggested that a course in "Fundamental Engineering" be established in engineering schools as an alternate course with present specialized courses. It is believed that with competent and enthusiastic faculties for this course its graduates will be so successful that eventually industry will demand engineers with this fundamental training.

College Notes

Charles Pratt, President of **Pratt Institute**, has announced his intention of retiring. He will, however, continue to serve until his successor is appointed. The Board of Trustees has signified its intention of electing him its chairman at that time, thus preserving the continuity of his service. Mr. Pratt, who is a grandson and namesake of the Founder of Pratt Institute, took over its chief administrative post from his father, the late Frederic B. Pratt, in 1937, and has been its executive officer during its transition from a technical institute to a degree-granting institution.

After eight months as Acting President of **Fenn College**, G. Brooks Earnest has been elected to the presidency of the Cleveland college.

A new Acoustics Laboratory where sound that man cannot hear, as well as audible noise, will be investigated has been established in the Engineering Center at **Columbia University.** When completed, the Laboratory will provide facilities for research and instruction in electroacoustics, architectural acoustics, ultrasonics, psycho-acoustics, speech, noise control, and musical acoustics.

Dexter S. Kimball

Dexter S. Kimball, former Dean of Engineering at Cornell University and a Past President of the American Society for Engineering Education, passed away on November 1, 1952. For more than half a century, Dean Kimball was one of the best known and best loved personalities on the Cornell faculty. He was nationally prominent in the field of engineering.

Dean Kimball was born in New River, New Brunswick, Canada on October 21, 1865. He received the A.B. degree in engineering from Stanford University in 1896 and the degree of mechanical engineer from Stanford in 1913. He held honorary degrees from the University of Rochester, Case School of Applied Science, Kansas State College, Northeastern University and Lehigh University.

He was honored by several scientific societies and received the Lamme Award from the ASEE in 1933.

The Modern Engineer Should be Educated as a Scientist. II. In College

By GORDON S. BROWN

Professor of Electrical Engineering, Massachusetts Institute of Technology

It is probable that you would take many young engineers by surprise if you told them that they should be educated as scientists. They would point out that engineers are men of decision, of accomplishment, that they get things done in the framework of the hard cold world. The significance of an education in science becomes clearer, however, if they appreciate first, that professional engineering is the application of the practical accomplishments of the scientist to the service of mankind, and second that engineering as practiced in the mid-twentieth century has a much more scientific flavor than it had only a few decades ago, and third that many scientists have demonstrated talents that present day engineers would do well to emulate. The words "as a scientist" then acquire a subtle meaning, but they should not be interpreted too narrowly for this discussion. It is more to the point to say that engineers should be educated "with depth in the sciences" rather than say "as a scientist."

If we take a look back and review the growth of technology as Professor Goodlet * has done in a paper he read before the Institute of Electrical Engineers of South Africa, we may note several significant facts. For example, throughout the period of the first industrial revolution, technology was such that many engineers succeeded in accomplishing great engineering feats—the building of bridges, the design and manufacture of heat engines, the weaving of cloth, the multitudinous systems of transportation, and even the wireless, in the face of an inadequate and often erroneous statement of basic theory. Many of the great inventions of our times came into being without the benefit of science, and often in spite of the predictions of eminent scientists.

But engineering and science are both relatively young and growing fields. It is only a mere two hundred years or so since systematic scientific research began to get a hold in the great universities of the world. While science was young and growing, common sense and intuition still found great scope for application in engineering. Up to about the turn of the century engineers were able to pioneer in many new fields even though they did not know all the fine points as to the why. Their problems were such that to know the how was sufficient, for their tasks were largely to perform orderly arrangements of the known experiences of their day. During this period much of the study by the physical scientists was concerned with the establishment of truth within the technical world then created by engineers. Then, as a consequence of these truths of the scientist there gradually spread throughout the various fields of engineering a demand for a quantitative exactness of statement about more and more things. Engineers soon learned the value of quantitative design as a substitute for empericism. The establishment, early in the 19th century, of professorships in engineering in universities and of the technical institutes that have since attained full in-

* Goodlet, B. L., "The Universities and the Engineering World." *Trans. S. A. Inst. Elect. Eng.*, Aug. (1950), 231.

ternational professional stature resulted largely from this demand for quantitative exactness.

Engineering is Complex

But the situation today is in marked contrast with what it used to be. The complexities of engineering technology and the demands for creative engineering are far greater than those of even a decade ago. A sharpening up of old emperical tools is no longer sufficient. Engineering has become vitally dependent on science, and abstract scientific analysis often calls the shots for engineering. As a result of the accumulated know-how of several generations of concentrated engineering aided by pure and applied scientific effort, we now have a vast store of fundamental knowledge. Thus, technical education as we think of it today has a digestion problem. Obviously, the solution is not merely to demand more of a student's time for professional study. In fact, modern demands for the education of the "whole engineer" resulting from the vast social influence he now wields, have encroached on the time formerly available for professional activities. What then has happened, what must happen in the years ahead?

Fortunately, we are aided in small degree by the feedback process inherent in our social system. The day-by-day activity of our youth is conducted in an environment that is heavily technical —in the home, in school, and even at play. The effect is to augment a young engineer's motivation for technical study. Then to, as the tempo of life has quickened, the high schools and preparatory schools have increased their skill at preparing boys for assimilating concentrated courses in mathematics, physics, chemistry, engineering, and humanities. But we cannot expect too much here and assume that high schools exist merely to prepare boys for college; their job is also to train youngsters for life. Neither can we assume that we have an inexhaustible pool from which to draw, for as Dean Hollister mentioned in his inspiring presidential address at the Annual Meeting at Dartmouth this summer we cannot expect any great increase in the percentage of high-IQ youngsters that will enter engineering. This situation is serious in the face of an increasing demand for engineers. Hence, we must make the most of those whom we get and upgrade them, technically and in creative capacity, above the level we have heretofore believed adequate.

Creative Synthesis

In making the most of what we can get we must not be deluded into thinking that our job is merely to turn out knowledgeable young men, walking encyclopedias, full of facts. On the contrary, we should aim to produce a person trained in basic principles and skilled at applying what we mean by creative synthesis in new complex engineering situation. The need is for composers in contrast with mere arrangers. To this end, the sifting of curricula content in colleges and universities must continue. Our faculties must comprise more outstanding men. Our skill at discriminating between fundamental fact and mere useful knowledge in terms of today's technology must continue upward. Above all, more and more of us must realize that the engineer of tomorrow cannot be a person who merely makes decisions and gets answers to today's problems. He must not be merely a high-powered technician. On the contrary, he must be that kind of professional individual whose knowledge of the modern fundamental discoveries of science is first rate; he must be able to sense those discoveries from which will spring the great new engineering developments of tomorrow; he must have experienced the thrill of creative accomplishment in an environment where the fundamentals of science are practiced. He must not have been reared on mere drill at problem solving. The decisions and answers he must make are those that pertain to the new and unplowed areas of applied technology if he is to attain the stature of a creative engineering leader of the mid-twentieth century. The forward looking engineers and educators of today clearly realize—

as Professor Goodlet says—that "science until recently the servant of engineering, is becoming its master and that advances in engineering are now often made not by engineers but by scientists."

As an illustration of the close coupling of science and engineering let us take a look at any of the present-day growing fields of science or those that have recently reached the domain of engineering. In the early phases, the topic was full of problems that were of a challenging abstract kind and attracted the attention of scientists who found opportunity for abstract theoretical thinking. Their efforts pointed up many problems that required scientific study and culminated in throwing up an umbrella of sound scientific thought. Working in concert with them were the people whom I call engineers. They knew their fundamentals, they were bold and creative and they had an urge to apply their efforts to today's needs. They in turn sifted, codified, and tabulated the scientific theories so that the issues eventually became clearer, the useful distinguishable from the interesting, and they applied the results to the benefit of society and industry. Finally great waves of people who are often called engineers, but who are perhaps better thought of as practitioners or technicians, were swept under this umbrella and produced, sold, and serviced the efforts of the engineers in the daily market. The engineers of whom I speak here will certainly not bother to argue the words—"trained as Scientists" or "trained in science."

Illustration

Another illustration of this close coupling is the importance that industry attaches to science and research and its dependence on them for sustained success. All organizations in the great industries of today, such as mechanical, electrical, chemical, aeronautical, maintain their own research organization or have their engineers keep abreast of the professional literature wherein the results of research in pure and applied science are reported. In modern times the new developments in industry result from the synthesis by engineers of new discoveries in pure and applied science. The interval from the time of discovery of new scientific phenomena and theories to their industrial exploitation is today only a matter of a few years at most. Because of this tempo, we have been forced into an operating system in which large groups of nonconformist engineer-scientist teams operate with a very clear plan of coordinated effort. You will agree, I hope, that any engineer who does not know his science would be a technically illiterate member of any such team.

But not every engineer trained as a scientist will practice engineering in the company of scientists or in a creative environment, or spend any of his own time in abstract thought. Many will be concerned wholly with bread and butter, or cookbook engineering rather than with the advancement of technology. A sound education in the sciences is an unnecessary if not an undigestible luxury for a cookbook engineer, but I would hope that engineering schools of the future will reduce to a minimum the number of cookbookers among their all to few students. Spoon-feeding with facts is not the whole aim of modern engineering education. Admittedly we must do some of it as part of an undergraduate program, in getting started so to speak, and certainly many students whom we admit will fail to measure up to our ideals yet still will serve humanity well. Our goal, however, must be to choose our raw material wisely, to salvage as many as possible from those who stumble along the way, and to offer graduate opportunities for as many as have the appropriate intellectual capacity.

Aims in Educating Engineers

An analysis of these situations leads to the conclusion that the education of the leading engineers for a creative professional career should have the same or nearly the same characteristics or qualities as the education of the scientist—with, however, the stipulation that it make them good engineers and not medi-

ocre scientists. That is to say, these engineers must, in addition to knowing science, know the practical world. Their concern is basically one of practical utility, but of tomorrow's vintage, not yesterday's. Their job is to satisfy the material needs and desires of people within their willingness or capacity to pay. They must be leaders of men. They must consider manufacturing problems, labor conditions, and above all have sound judgment. They cannot be mere tradesmen or technicians, since they must make use of the accumulated knowledge and techniques of the mathematician and the scientist, as well as use all the tricks of their own trade. While being primarily interested in knowledge because it is useful, in contrast to the scientist who is interested in knowledge to uncover the truth about the real world, they do not restrict all their interest to knowledge that is useful today. Their sights are upward—they clearly have their eyes set on tomorrow.

So much for the aims. As educators how well do we live up to them? Two general matters will bear discussion, namely, (1) as science advances and as engineering becomes more scientific do we keep up-to-date in the matter of curriculum substance, and (2) do we create as often as we should the best environment for teaching engineering?

On the question of curriculum take for example the situation that exists now in college physics. The last decade has witnessed a tremendous growth in so-called modern physics with the birth of atomic physics and physics of the solid state, just to cite two new fields. A knowledge of both is important to modern engineers. But the curriculum hours for teaching physics are limited. Hence it is essential that we review the distribution of academic effort within the science and engineering departments as a continuing activity and be constantly alert to opportunities which would result in the engineering departments teaching much of the classical physics as an integrated part of engineering, while the physics departments use their allotment of time to teach modern physics to engineers. Because of the heavy expenditures of time and money associated with any program of modernizing laboratory courses, I suspect that many of us have failed to incorporate in engineering laboratory courses much subject matter that is now taught in freshman and sophomore physics laboratory just because it always has been, when actually it could greatly strengthen the engineering subject.

Similar remarks can be made about the teaching of mathematics. As engineering has continued to upgrade, the substance of mathematics has become more and more an integral part. Not many years ago function theory, operational methods, Fourier transforms, and Fourier series were taught exclusively by the mathematic departments. They were rarely used or even mentioned by engineers, except perhaps in graduate work. Now they have become indispensible tools in engineering subjects such as circuit theory, applied mechanics, and so forth. Mathematics courses for engineers have thus been freed to treat more advanced topics and give more training in abstract thought.

Improvement in Teaching

In spite of all the ASEE meetings that discuss the teaching of engineering we still observe need for improvement. The substance may be all right but the subject often does not take. Is it because we fail to give the student those concepts that will allow him to be creative and fail to show him how to use them? Do we stop short in presenting fundamentals in order to reach the handbook stage of so-called engineering design? Do we teach rather than educate? Speaking strictly as an electrical engineer, it seems to me that many students graduate with a wholly inadequate understanding of modern field theory. To many it appears as a useless scientific abstraction. While most students can handle a statics problem such as plotting a field distribution or designing a simple electromagnet, too many are stopped dead in their tracks when the problem is made dynamic by introducing

time as a variable with attendant space propagation. The general rule seems to be that only students in the communications option are expected to take field theory seriously, and these limit their interest wholly to radio. Perhaps the advent of the transistor, and the wide engineering interest in physics of the solid state will improve this situation. As another example, witness the recent state of the teaching of electrical machinery. Many subjects are limited to the treatment of the machine in the static state. There is great preoccupation with steady-state performance. There is rarely much substance that allows a student to be creative about unusual combinations of fields and conductors, especially those that might exploit non-linearities. More recently an emphasis on the machine as an energy conversion element † in a system has emerged. Also the subject of feedback control has aroused a greater interest in the dynamics of machine behavior with the machine here relegated to the status of a circuit element in a complicated energy conversion system. While some detailed understanding of the design technique of specific elements of a routine nature may have been lost in this evolutionary process, it seems to me that the student may be better educated since his emphasis on the system problem and his guidance in abstract thinking have been increased.

Need to Develop Wisdom

Fortunately, however, communication within academic and engineering circles is sufficiently effectual that in so far as curriculum substance is concerned there is little point to an extensive discussion. Our concern is not primarily with how well we present our facts and figures or how well we build up the student's knowledge. Rather, it is with, how well we succeed in training him to use his mind, or with how well we inculcate in him the so-called scientific method and give him the collatoral capacity to think creatively in the abstract about basic fundamentals as he works with his facts and formulae. In other words, our concern is whether we achieve any development of wisdom in addition to imparting knowledge. And the two are vastly different as so beautifully described by Cowper:

"Knowledge and wisdom, far from being one,
Have ofttimes no connexion. Knowledge dwells
In heads replete with thoughts of other men,
Wisdom in mind attentive to their own.
Knowledge, a rude unprofitable mass,
The mere materials with which wisdom builds,
Till smoothed and squared and fitted to its place
Does but encumber whom it seems to enrich.
Knowledge is proud that he has learned so much;
Wisdom is humble that he knows no more." ‡

While we must not deprecate the importance of factual information to an engineer, the item of greatest importance to this discussion is that whereas it has long been accepted that embryo scientists shall have training in research while in college, the training of embryo engineers in research, or perhaps development, on an organized basis is a relatively recent innovation. In fact, at the level that I believe it should be practiced, I doubt if it is at all widespread. In many institutions there is no thesis requirement for a B.S. degree in engineering while in others, thesis is not even required for an M.S. degree. In too many instances, the student attends lectures, performs canned experiments, and solves problems closely related to the specific course for his entire four years. At no time does he have the need, let alone the urge, to synthesize from several different fundamental concepts, to create as an engineer. His efforts are wholly those of analysis limited to fragments of a problem.

But powerful forces are at work within engineering and science that offer many

† A. E. Fitzgerald and Charles Kingsley, Jr., "Electrical Machinery." An integrated treatment of AC and DC machines. McGraw-Hill Book Co., Inc. 1952.

‡ William Cowper, "The Task," Bk. VI, lines 88–98, 1785.

precious opportunities for helping both teacher and student. Not only has the sustained cold war promoted an extensive amount of government sponsored research in educational institutions, but many industries have realized that they must sponsor research in educational institutions for their own protection. I hope the public utility and power industries come to this realization before vitality and creative thinking in their field disappears completely from engineering schools.

Major Change in Thinking

Perhaps without fully realizing it we are on the threshold of witnessing a major change in our thinking. The recent summer meeting of the ASEE held an interesting panel discussion on, "Training in Research." Speakers discussed "thesis and seminar," "sponsored research," "training in research," and related topics such as "pure versus applied," "the right atmosphere," and so forth. The speakers all talked freely about the wonders of the scientific method and of the integrating value of research in so far as it tied together the various fundamentals of a curriculum; of the experience it gave in organizing an attack on a problem as the researcher filtered, decoded, rejected, interpreted, synthesized, and decided; of the effectiveness with which research brought opportunities for new abstract thinking into the environment of the engineer. The speakers were faculty members of American engineering colleges. Some were engineers, others were scientists. What they all were saying was that participation in a live enterprise in a creative scientific environment, with fertile opportunity for abstract thinking where men were not afraid to do new things and tread unworn paths, was good education. It seems to me that they were affirming the objective of this panel discussion under a different title.

Research or development projects in both engineering and science performed on campus under the supervision of a faculty member are priceless adjuncts to an institution's program. It is important that we insist, however, that the projects be such that a student can work as an assistant to a faculty member, or be a member of the engineering team and have the thrill of being part of a creative environment. In many instances he can handle a segment of the problem on his own as a thesis. In either case, he is withdrawn for awhile from the treadmill of taking courses and given a chance to stand on his own feet. If properly guided he can be given the collatoral experience of seeing the whole problem, seeing how subtly and surely its solution cuts across many fields of specialization and thereby see, perhaps for the first time, the interrelationships of substance within his curriculum. He can note how the problem is often first scanned in terms of such simple concepts as energy balance—kinetic, potential, thermal, chemical, electromagnetic, and so forth—that it involves measurement if it is to be specific, and energy conversion if it performs useful work in the real world, that the whole problem can be first examined in a pseudo abstract sense, that the tools of the mathematician permit effective abstract thought, that there often exist analogies of the whole situation in other fields. In several instances, he will see that the tempo of technology is so great that the engineer cannot wait for the scientist to get the answers to basic questions, so he must pinch hit himself as a scientist. When such conditions exist within faculties of engineering schools, the student both undergraduate and graduate, has an excellent experience if he can be cut in on the enterprise. Finally, if the problem is creative in an engineering sense, the student will see that it takes years to reach an objective, that he must be alert to the temptation to substitute lower standards of accomplishment for persistence and patience, and that in the appraisal of the multitudinous questions for which no quantiative data exist there appears the opportunity for the application of that something called *sound engineering judgment*, a vital characteristic of all good engineering.

Sponsored Research

Perhaps not all institutions are willing to have the kind of engineering enterprise on their campus that will provide such an environment. I hold the opinion that modern engineering education needs this kind of *environment* for the learning of today's substance and that society should see to it that all the schools which can, do. I do not think that so-called cooperative courses, where the student is a term at school and a term at the works, wholly meet the needs of the times though they are important in themselves. While they offer an opportunity for participation in an engineering environment, only rarely is it as broadly creative as a college campus can offer. The questions that should be asked when making a choice of project are not whether it is basic or fundamental, applied research or development, but whether:

A. The institution has in existence or potentially available the facilities and staff needed for the work?
B. The faculty has a strong interest in this kind of work, and whether it would both broaden and deepen their scholarship?
C. The program falls within the areas of activity covered by the educational program?
D. The activity will offer the opportunity for student participation?

The question of research or development work under government or industrial sponsorship is one that institutions and industry should face squarely.§ While some commercial organizations may be hostile toward university participation in their fields, it cannot be denied that challenging development work on a paid job under a professor's direction is an extremely valuable educational experience for the graduate. It can considerably enhance his usefulness as a member of an industrial organization. The general idea here expressed has for decades been in widespread use in the medical profession in the program of internship undertaken by young doctors of medicine before entering private practice. Furthermore, the vitality and professional flavor of the academic engineering environment can be advantageously nourished by close and flourishing industrial association. The flight of dynamic professors from the university to industry can often be retarded by establishing on-campus engineering research. Clearly, an institution should demand the opportunity to cultivate such association without surrendering academic freedoms and the right to publish. It should insist on a tempo of activity that will permit of student participation at a pace commensurate with an academic program, and should assure itself that the effort will contribute to the academic strength of the institution rather than merely solve an industrial problem. If it holds to these requirements it will not be trespassing on the prerogatives of commercial research organizations. Obviously, no stigma should attach to an academic thesis performed on a paid job. I firmly believe in development engineering enterprises within college departments, such as servomechanisms laboratories wherein genuine engineering responsibility is accepted, just to cite one I know well, if modern engineering graduates are to be trained to the level of professional competence that the times necessitate. I do not believe we go far enough when we assign to engineers only small fragmentary so-called basic problems. They may be all right if we are only searching for truth, but they are rarely comprehensive enough to exploit fully the capacity of the engineer for creative synthesis.

Case Method

Closely allied to the general problem of research is the technique of engineering instruction by the project or case method. Specific cases do not need to be new original problems in order to be a substitute for research when considered in relation to the student's state of knowledge.

§ Sherwood, T. K., *Chem. and Eng. News*, Am. Chem. Soc. 2 (1950), v. 28, p. 456.

This is particularly true of undergraduates. Often the best examples emerge from faculty participation in research. Professor E. P. Neumann of the Mechanical Engineering Department at MIT demonstrated this a year or so ago. A group of his undergraduate students studying thermodynamics were assigned the problem of maintaining the cockpit temperature in a supersonic aircraft at a level that would be acceptable to the pilot. The group was told to absent themselves from the regular classroom session in thermodynamics while they handled this problem. Their accomplishments were startling to say the least. Not only did they learn to apply the principles of thermodynamics, but they uncovered and applied principles usually learned in other fields but which were here part of the problem. They had to learn about supersonic air flow, especially as related to thermodynamics. They found it necesary to discuss the problem with people of various professional backgrounds. At the end of the term they took the regularly scheduled final examination and did essentially as well as the better students who studied the regular subject. Instead of submitting to the usual experience of covering so many thermodynamic principles, they actually uncovered a few on their own. While the topic was one in which academic achievement could be quantitatively assessed by the instructor, it brought into focus in a very real way several associated disciplines of engineering, for it necessitated that the student obtain quantitative answers to real problems on a time schedule and subject to the limitations of engineering feasibility, economics, good common sense, and so forth.

On another occasion a group of electrical seniors were assigned the task of designing and promoting commercially a gas-discharge flash light for amateur photographers. Still another group of mechanicals tackled an improved design of commercial vacuum cleaner. Each project cut across many fields of specialization and introduced both technical and non-technical problems of a creative kind.

Summary

In conclusion, let me summarize my contentions as follows. Modern professional engineering is the application of natural laws and phenomena to the service of man. It leans heavily on the modern discoveries of physics, mathematics and chemistry. The future promises such heavy demands on engineers that the best of those whom we train must be developed to the highest state of professional skill commensurate with their latent talents and the capacity of educators to develop them. This calls for extensive training of engineers in depth in the associated fields of science in a creative environment under the guidance of a faculty which itself is creative. In addition to the inclusion of strong basic science courses, the curriculum should offer substantial scope for student participation in research or make frequent use of the case method of instruction with creative examples as a means of illustrating the application of modern science to engineering work.

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny	West Virginia University	April 17–18, 1953	C. H. Cather, West Virginia University
Illinois-Indiana	Rose Polytechnic Institute	May, 16, 1953	H. A. Moench, Rose Polytechnic Institute
Kansas-Nebraska	University of Kansas	Oct. 24–25, 1952	M. A. Durland, Kansas State College
Michigan	Detroit Institute of Technology	May 9, 1953	C. C. Winn, Detroit Institute of Technology
Middle Atlantic	Manhattan College	December 6, 1952	W. B. Plank, Lafayette College
Missouri	Washington University	April 11, 1953	G. F. Branigan, University of Arkansas
National Capital Area	Catholic University of America	Oct. 7, 1952	L. K. Downing, Howard University
	Howard University	May 9, 1953	
	University of Maryland	Feb. 3, 1953	
New England	Worcester Polytechnic Institute	Oct. 18, 1952	E. T. Donovan, University of New Hampshire
North Midwest	Marquette University	Oct. 9–10, 1953	S. J. Chamberlin, Iowa State College
Ohio	University of Cincinnati	May 2, 1953	H. K. Justice, University of Cincinnati
Pacific Northwest	Washington State College	April 24–25, 1953	J. P. Spielman, Washington State College
Pacific Southwest	California State Polytechnic College	Dec. 29–30, 1952	C. E. Cherry, College of Marin
*Rocky Mountain	University of Wyoming		C. A. Hutchinson, University of Colorado
*Southeastern	Louisiana State University	March, 1953	D. V. Terrell, University of Kentucky
Southwestern	University of New Mexico	April 3 & 4, 1953	M. L. Ray, University of Houston
Upper New York	Alfred University	October 10–11, 1952	R. M. Campbell, Alfred University

Members of the Society are welcome at all Section Meetings

*** No Date Set.**

New Members

ABRAMSON, HYMAN N., Act. Associate Professor of Aeronautical Engineering, Texas A. & M. College, College Station, Texas. H. W. Barlow, E. E. Brush.

ALLING, EDWIN S., Assistant Professor of Civil Engineering, University of New Hampshire, Durham, N. H. E. T. Donovan, R. R. Skelton.

ALMFELDT, MAURICE W., Associate Professor of Engineering Drawing, Iowa State College, Ames, Iowa. J. S. Rising, C. G. Sanders.

ATHERTON, RICHARD, Assistant Professor of Mechanical Engineering, University of Massachusetts, Amherst, Mass. J. B. Longstaff, J. H. Dittfach.

BASSOE, BJARNE, Secretary General, The Norwegian Engineering Society, Oslo, Norway. C. E. Davies, A. B. Bronwell.

BERNARDI, SALVATORE D., Assistant Professor of Mathematics, New York University, New York, N. Y. H. A. Giddings, I. A. Carl.

BIEDENBACH, JOSEPH M., Instructor in Science Department, General Motors Institute, Flint, Mich. G. L. LaPrade, J. B. Keehner.

BIGELOW, CLIFFORD G., Assistant in Industrial Engineering, Columbia University, New York, N. Y. F. C. Winter, S. J. Montgomery.

BURNHAM, GEORGE H., Associate Professor of Physics, Norwich University, Northfield, Vt. S. Rubinsky, S. N. McIntire.

CARLSON, EHRET C., Instructor in Advanced Engineering Education, International Business Machines Corporation, Fishkill, N. Y. R. W. Wolslegel, E. E. Moyer.

CHINN, JAMES, Assistant Professor of Civil Engineering, University of Texas, Austin, Texas. P. M. Ferguson, W. L. Moore.

COLLINS, STEWART B., Assistant Professor of Industrial Coordination, Drexel Institute of Technology, Philadelphia, Pa. H. R. Bintzer, C. A. Kapp.

DAVIS, EARLE R., Professor and Head, English Department, Kansas State College, Manhattan, Kans. M. A. Durland, L. Helander.

EGNER, CARL A., Associate Professor of Civil Engineering, Purdue University, Lafayette, Ind. F. W. Stubbs, Jr., R. B. Wiley.

EL-MELEHY, M. A., Assistant Professor of Electrical Engineering, University of Arkansas, Fayetteville, Ark. G. F. Branigan, N. H. Barnette.

FEDORCHUCK, HENRY N., Assistant in Mechanical Engineering, University of Detroit, Detroit, Mich. H. Gudebski, W. P. Godfrey.

FOSTER, ARTHUR R., Assistant Professor of Mechanical Engineering, Northeastern University, Boston, Mass. A. J. Ferretti, H. K. Brown.

GENSAMER, MAXWELL, Professor of Metallurgy, Columbia University, New York 27, N. Y. J. M. Garrelts, P. B. Bucky.

GERSHON, JOSEPH J., Director of Engineering, DeForest's Training, Inc., Chicago, Ill. A. B. Bronwell, O. I. Thompson.

GMEINER, PAUL, Instructor in Advanced Engineering Education, International Business Machines Corporation, Poughkeepsie, N. Y. R. W. Wolslegel, E. E. Moyer.

GODDARD, WILLIAM E., Vice President and General Manager, Canadian Institute of Science & Technology, Ltd., Toronto, Ontario, Can. E. A. Allcut, W. P. Ferguson.

HULTQUIST, PAUL F., Instructor in Applied Mathematics, University of Colorado, Boulder, Colo. C. L. Eckel, C. A. Hutchinson.

JOHNSON, RAY C., Instructor in Mechanical Engineering, University of Rochester, Rochester, N. Y. R. R. Kraybill, R. F. Eisenberg.

KLUGE, RALPH W., Professor of Civil Engineering, University of Florida, Gainesville, Fla. J. E. Kiker, Jr., T. L. Bransford.

LADD, ROGER E., Massachusetts Institute of Technology, Cambridge, Mass. T. F. Jones, Jr., D. C. Ladd.

LANG, WILLIAM A., Manager, Educational Assistance Dept., Minneapolis-Honeywell Regulator Co., Philadelphia, Pa. W. J. Stevens, K. W. Riddle.

LANHAM, FRANK B., Assistant Secretary, American Society of Agricultural Engineers, Saint Joseph, Mich. H. J. Barre, R. Olney.

LANZ, LOUIS T., Coordinator, Technical Personnel Procurement Dept., Monsanto Chemical Company, St. Louis, Mo. R. F. McCook, J. J. Healy, Jr.

LEWELLEN, JAMES G., Assistant in Aeronautical Engineering, Parks College of Aero. Tech., East St. Louis, Ill. N. C. Beck, H. R. Grummann.

LEWIS, LAVERNE F., Associate Professor of Physics, U.S.A.F. Institute of Technology, Dayton, Ohio. J. H. Belknap, H. F. Marco.

LINTON, FRANKLIN H., Director of Placement, Wentworth Institute, Boston, Mass. W. C. White, M. N. Arlin.

LISK, HAROLD H., Director, Publications Dept., Norden Laboratories Corp., White Plains, N. Y. W. R. Woolrich, A. B. Bronwell.

LOTTICH, PHILIP B., Director of Admissions and Coordinator of the Cooperative Program, Illinois Institute of Tech., Chicago, Ill. J. G. Duba, R. G. Owens.

LUNDERGAN, CHARLES D., Acting Head, Dept. of Aeronautical Engineering, Parks College of Aero. Tech., East St. Louis, Ill. N. C. Beck, H. S. Wood.

LYNCH, WILLIAM A., Associate Professor of Electrical Engineering, Polytechnic Institute of Brooklyn, Brooklyn, N. Y. C. C. Whipple, J. W. Hostetter.

MACKSON, CHESTER J., Instructor in Agricultural Engineering, Michigan State College, East Lansing, Mich. W. O. Carver, W. M. Carleton.

MARCUS, JOSEPH S., Assistant Professor of Civil Engineering, University of Massachusetts, Amherst, Mass. M. P. White, G. A. Marston.

MARSHALL, W. R., JR., Associate Professor of Chemical Engineering, University of Wisconsin, Madison, Wis. R. J. Altpeter, R. A. Kirk.

MCCALEB, OMER K., Coordinator of Industrial Arts, Reedsport Union High School, Reedsport, Ore. G. B. Cox, R. M. Lockwood.

MCCLUNG, ALFRED R., Assistant Professor of Electrical Engineering, West Virginia Institute of Technology, Montgomery, W. Va. P. H. Renton, M. J. Horsch.

MCFALL, RUSSELL W., Manager, Technical Education Services Dept., General Electric Company, Scotia, N. Y. K. B. McEachron, Jr., G. A. Rietz.

MCKEE, JEWEL C., JR., Associate Professor of Electrical Engineering, Mississippi State College, State College, Miss. H. C. Simrall, H. P. Neal.

MERCHANT, JOHN A., Registrar, Association of Professional Engineers of the Province of British Columbia, Vancouver, B. C., Canada. R. E. Wilkins, A. D. Creer.

MICHENER, CHAS. T., Assistant Professor of Engineering, Pennsylvania Military College, Drexel Hill, Pa. D. H. Pletta, L. O'Shaughnessy.

MONISMITH, CARL L., Instructor in Civil Engineering, University of California, Berkeley, Calif. J. B. Franzini, E. P. Popov.

MORSE, FREDERICK B., Instructor in Mechanical Engineering, Purdue University, Lafayette, Ind. H. L. Solberg, F. C. Hockema.

NAIL, PAUL L., Instructor in Radio Theory Dept., Central Radio & Television Schools, Kansas City, Mo. C. L. Foster, N. E. Vilander.

NEDDERMAN, WENDELL H., Associate Professor of Civil Engineering, Texas A.&M. College, College Station, Texas. R. L. Peurifoy, H. J. Miles.

OETJEN, J. EDWARD, Assistant Professor of Mechanical Engineering, University of Cincinnati, Cincinnati, Ohio. R. T. Howe, R. L. Smith.

PETERSON, EMIL J., Assistant Commandant, The Engineer School, U. S. Army, Fort Belvoir, Va. W. N. Underwood, T. R. Jones.

PICKARD, EDWARD E., Educational Advisor, The Engineer School, U. S. Army, Fort Belvoir, Va. W. N. Underwood, T. R. Jones.

PRICE, WILLIAM J., Associate Professor of Physics, U.S.A.F. Institute of Technology, Dayton, Ohio. J. H. Belknap, H. F. Marco.

READ, THOMAS A., Associate Professor of Metallurgy, Columbia University, New York, N. Y. J. M. Garrelts, P. B. Bucky.

REIS, IRVING L., Assistant Professor of Mechanical Engineering, and Supervisor of Institutes, University Extension Division, University of Nebraska, Lincoln, Neb. N. H. Barnard, J. K. Luewickson.

RIDDLE, ROBERT L., Assistant Professor of Electrical Engineering, Pennsylvania State College, State College, Pa. V. E. Neilly, K. L. Holderman.

ROBERTS, ERSKINE G., Consulting and Designing Engineer, Indianapolis, Indiana. C. L. Curtis, H. K. Downing.

SCHNEIDER, WALTER L., Instructor in Mechanical Engineering, New York Univer-

sity, New York, N. Y. A. H. Church, E. A. Salma.

SCHOENBERGER, ROBERT L., JR., Instructor in Machine Design, Purdue University, Lafayette, Ind. A. R. Holowenko, F. J. Bogardus.

SCHON, JAMES F., Instructor in Engineering, City College of San Francisco, San Francisco, Calif. J. B. Franzini, A. E. Edstrom.

SENNE, JOSEPH H., JR., Assistant Professor of Civil Engineering, Missouri School of Mines and Metallurgy, Rolla, Mo. C. L. Wilson, J. B. Butler.

SETZKE, HENRY A., Instructor in Electronics, DeForests Training, Inc., Chicago, Ill. O. I. Thompson, J. A. M. Lyon.

SMITH, DAVID B., Associate Professor of Civil Engineering and Assistant Director, Engineering & Ind. Experiment Station, University of Florida, Gainesville, Fla. J. E. Kiker, Jr., T. L. Bransford.

SOWARBY, A. JOHN, Instructor, Division of Advanced Engineering Education, International Business Machines Corp., Poughkeepsie, N. Y. R. W. Wolslegel, E. E. Moyer.

VAN ANTWERPEN, FRANKLIN J., Editor, American Institute of Chemical Engineers, New York, N. Y. C. G. Kirkbride, J. S. Walton.

WARLAM, ARPAD A., Adjunct Associate Professor of Civil Engineering, New York University, New York, N. Y. G. G. Kubo, N. Porter.

WEIDMANN, GEORGE P., Associate in Graphics, Columbia University, New York, N. Y. G. M. Allen, H. W. Vreeland.

199 new members elected this year

* * *

Pacific Southwest Meets at San Luis Obispo

The Pacific Southwest Section of the Society plans its 1952 annual meeting for Monday and Tuesday, December 29 and 30 at the California State Polytechnic College at San Luis Obispo, California. Members residing in the States of California, Arizona, Nevada and New Mexico and the Territory of Hawaii are assigned to this section. A program is being arranged under the chairmanship of C. M. Duke of the University of California, Los Angeles, in keeping with the society's theme the "Year of Evaluation." About twenty offers of papers have been received to date. Harold Holmes of California State Polytechnic College is Arrangements Chairman, Carlton E. Cherry, C. M. Duke, and Joseph B. Franzini are Chairman, Vice Chairman and Secretary of the section respectively.

* * *

Now Available . . .

Reprints of the **Report of the Committee on Improvement of Teaching** which appeared in the September, 1952 Journal of Engineering Education. Checks and orders should be sent to the Journal of Engineering Education, Northwestern University, Evanston, Illinois. The price is $8.00 per hundred and 15¢ per copy in quantities under 100.

Young Faculty Members . . . . .

PAPER COMPETITION

ELIGIBILITY: Members of ASEE not over 36 years of age in June, 1953.

AWARDS: First prize $200—Second prize $100.
Awards will be presented to recipients at the Banquet at the Annual Meeting of ASEE, University of Florida, June 25, 1953.

SUBJECT: Papers should deal with some constructive phase of improvement of engineering education. Participants are encouraged to select their own subject matter and titles within the broad framework of improvement of engineering education. In general, the papers should not be of a technical nature. The following are suggestions of the type of subject matter to consider:

a. How can the student learn to deal with new and unfamiliar situations with originality and well-ordered professional thinking?

b. What are the most important qualifications of undergraduate teachers of engineering?

JUDGING: Each Section will appoint its own judging committee and select one winning paper. The winning papers from the Sections will be reviewed by a national judging committee for the final awards.

SUBMISSION OF ENTRIES: Papers can be submitted to the folowing persons in the ASEE Section in which the participant resides:

Section	*Final Date*	*Submit Entry To:*
Allegheny	April 1, 1953	L. Zee, West Virginia University, Morgantown, W. Va.
Missouri	April 1, 1953	F. H. Conrad, School of Mines, Rolla, Mo.
National Capital	March 3, 1953	L. K. Downing, Howard University, Washington, D. C.
North-Midwest	April 1, 1953	S. J. Chamberlain, Iowa State College, Ames, Iowa
Ohio	March 14, 1953	H. K. Justice, University of Cincinnati, Cincinnati, Ohio
Pacific-Northwest	March 15, 1953	J. P. Spielman, State College of Washington, Pullman, Wash.
Rocky Mountain	March 10, 1953	R. E. Leffel, University of Colorado, Boulder, Colo.
Southeastern	Feb. 27, 1953	M. Baker, University of Kentucky, Lexington, Ky.
Southwestern	April 2, 1953	R. D. Slonneger, University of Houston, Houston, Tex.
Upper New York	March 15, 1953	A. D. Taylor, 18 Campus Drive East, Snyder 21, N. Y.

The following Sections have not indicated a final date for entries, but papers submitted prior to March 15 will be considered:

Illinois-Indiana	—	H. A. Moench, Rose Polytechnic Institute, Terre Haute, Ind.
Kansas-Nebraska	—	M. A. Durland, Kansas State College, Manhattan, Kans.
Michigan	—	C. C. Winn, Detroit Inst. of Technology, Detroit, Mich.
Middle Atlantic	—	W. B. Plank, Lafayette College, Easton, Pa.
New England	—	E. T. Donovan University of New Hampshire, Durham, N. H.
Pacific-Southwest	—	C. E. Cherry, College of Marin, Kentfield, Calif.

THE T-SQUARE PAGE

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Midwinter Meeting
of the
Engineering Drawing Division of the A.S.E.E.
University of Nebraska, Lincoln, Nebraska
January 29, 30, and 31, 1953

The Drawing Division was invited to hold its Midwinter Meeting at the University of Nebraska during the annual meeting at East Lansing, Michigan. The Executive Committee accepted this offer and fixed the dates of January 29, 30, and 31, 1953. The program includes:

Thursday, January 29:

9:00–10:30 a.m.	Registration, 2nd Floor, Bancroft Building
10:30 a.m.	Meeting, Auditorium, Bancroft Building
	Greeting: Dean Roy M. Green, College of Engineering and Architecture, University of Nebraska
	Response: (For the Division) Dean Jasper Gerardi, Chairman of the Division
	"Reduction of Forces in Space by Graphical Methods," Professor E. J. Marmo, Department of Engineering Mechanics, University of Nebraska
12:00 noon	Luncheon, Student Union
1:00– 1:15 p.m.	Board Buses for Boys' Town
	(Arrive at Boys' Town about 2:40)
2:50– 4:30 p.m.	Inspection of Boys' Town
4:30 p.m.	Board Buses for Lincoln
	(Arrive at Lincoln about 6:00)
7:00 p.m.	Executive Committee Meeting
8:00–10:00 p.m.	Informal get-together, Faculty Lounge, Student Union

Friday, January 30:

9:00–10:00 a.m. Inspection of College of Engineering and Architecture facilities

10:00 a.m. Meeting, Ferguson Hall, Room 215

1. "Opportunities and Responsibilities of Drawing in an Engineering Educational Program," Professor John T. Rule, Chairman, Section in Graphics, M.I.T.
2. "Graphical Methods for Radium Needle Dosage Calculation in the Treatment of Cancer," Howard W. Vreeland, Assistant Professor of Graphics, Columbia University
3. "Effect of Emphasizing Time in the Teaching of Engineering Drawing," Professor Maurice F. Richards, Santa Barbara College

12:00 noon Luncheon, Student Union

1:15– 3:15 p.m. Inspection Trip to Elgin Watch Company

3:15 p.m. Board Buses for State Capital

3:30– 4:30 p.m. Inspection of State Capital

6:30 p.m. Annual Dinner (Men and Women), Student Union
Speaker: R. G. Gustavson, Chancellor, University of Nebraska

Saturday, January 31:

8:45 a.m. "Manufacturing and Design Problems," Elgin Watch Company, followed by discussion

9:00 a.m. "A Short Terminal Course in Technology," Lyle E. Young, Minnesota Institute of Technology

9:30 a.m. Panel Discussion, "Objectives of a Department of Engineering Drawing" by panel members, C. I. Carlson (University of Illinois); W. E. Street (Texas A.&M.); H. P. Skamser (Michigan State); C. G. Sanders (Iowa State); J. S. Rising (Iowa State), Moderator

12:00 noon Luncheon, Student Union

Financing Engineering Education*

By JOHN D. MILLETT

Executive Director, Commission on Financing Higher Education, and Professor of Public Administration, Columbia University

Sponsored by the Association of American Universities and financed by grants from the Rockefeller Foundation and Carnegie Corporation, the Commission on Financing Higher Education was a private *ad hoc* agency set up for the sole purpose of making a study and reporting its conclusions about the financial problems confronting higher education today. The Commission carried on its work between 1949 and 1952, held its final meeting in July of this year, and has gone out of existence with the completion of its work.

One of the first conclusions we reached was that the financial problems of higher education must be analyzed in the first instance in terms of programs. To be sure, all the work of higher education is conducted through particular and individual institutions, whether they be universities, separate colleges, or separate professional schools. Although each of these is a self-contained financial unit, we have found in the course of our inquiry that their financial well-being must be considered in terms of the educational programs they provide. There are complications in this kind of analysis; thus the separate liberal arts college faces substantial financial difficulties which do not confront the liberal arts colleges of most universities, at least not in the same degree. The few separate medical schools still existing in this country, for various reasons, have financial problems different from those of medical schools in universities.

Let me illustrate with a few figures applying to engineering education. From the information I have there were 135 institutions with accredited engineering curricula in 1950. Of these 135 institutions, 92 were universities (57 public and 35 private), 11 were liberal arts colleges (1 public and 10 private), and 32 were separate engineering schools (18 public and 14 private). This variety of institutional settings has certain definite advantages. It means that there is considerable diversity in the environment and in the methods of engineering education; different institutions have somewhat different objectives or emphasis, such as upon instruction and research, and serve somewhat different clienteles; competition proves useful for education as for other types of enterprise.

Now institutions which offer very different kinds of educational programs cannot be compared financially, one with the other, as institutions. Their total cost figures or their total income figures are meaningful only in terms of the educational objectives they serve to realize, whether these be liberal, professional, or graduate study, or research. Accordingly, we have endeavored in our studies, insofar as possible, to think in terms of programs first and of institutions secondly.

To be sure, engineering education is one of the important professional programs of higher education in this country. It is one of the programs whose financial problems must therefore be analyzed in terms of the objectives, costs, and sources

* Condensed from a luncheon address at a joint meeting of the American Society for Engineering Education and the Engineers Council for Professional Development, Sheraton Hotel, Chicago, September 5, 1952.

of income peculiar to engineering education, regardless of its institutional setting. And there are certain common characteristics or certain common elements in the financial condition of engineering education wherever it is conducted.

Cost Problem

This brings me to the second point I wish to emphasize. A cost problem in higher education occurs when income for the support of a particular activity or institution is insufficient to meet the expenditures entailed in the operation. Because a particular educational program expends more money per student than another does not necessarily mean that the program is a cost problem. For example, the theological education of ministerial students is a high-cost program. It is not a cost problem because gift support from church denominations has generally met all the costs of providing theological education.

Medical education certainly entails no greater expenditure to an institution than does graduate education for the Ph.D. student in chemistry or physics. But medical education is by far the greater cost problem for higher education because sources of income have not been able to match expenditures. Indeed, of all fields of professional education, the experience of medical education is the most instructive for the college and university administrator concerned with costs and income.

Unquestionably, medical education is one of the outstanding contributions of all higher education. Some forty or fifty years ago medical educators, foundation officials, and leaders of the medical profession made quality the goal of medical education. The proprietary medical school was forced out of existence, the separate medical school was absorbed within the organizational framework of universities in order to give emphasis to medical scholarship, the number of medical schools was reduced, admission standards were raised, the period of medical education was lengthened, the curriculum was given a more or less set pattern founded upon such fundamental knowledge as existed in the biological sciences, the student-faculty ratio was lowered, and new attention was given to promotion of medical research. Insofar as educators have been able to agree, these are the elements which still go to make quality education in any field.

All of this effort costs money. Foundations and philanthropists were generous in their endowment support of medical education for a number of years. But in the past twenty years medical educators have clung to their concepts of high standards without evidencing an equal concern for adequate sources of financing. The result has been to create a crisis in financing medical education. Foundations and the federal government have offered large sums of money to finance research, but have defrayed only direct project costs. Indirect costs of plant maintenance and administrative overhead have had to come from general income. Mounting research expenditures have made medical schools research "poor," because they have not had corresponding increases in general income. Medical faculty salaries have gone up with increased remuneration from private practice, instructional supplies cost more, the medical curriculum has frayed out into more and more specialization. All of these developments mean more expense, which must be met by more income.

Higher education has no choice but to operate with a balanced budget. Medical education in public and private institutions has been kept at a high level of quality only at the price of diminishing the income available for other educational programs. Administrator after administrator in state universities and private institutions has testified to this fact.

The medical profession has taken great pride in the standards which medical education maintains in this country. But it has not manifested any equal concern with the costs which these standards entail, and

has assumed no real responsibility for finding ways and means to provide the income which medical education so direly requires today.

The third point I would make is this. As of the present time engineering education is not a major cost problem. As expenditures have risen, income has thus far been sufficient to meet required levels of outlay. The federal government has provided extensive research income, and the procurement regulations of the armed forces give adequate recognition to the element of indirect cost. Business corporations have recognized their direct interest in engineering education, and as the whole idea of corporation philanthropy has grown, engineering education has obtained a good proportion of these gifts, for current operations, for endowment, for capital plant, and for student aid. Increases in student fees and the generous support of higher education by state governments have also provided income to engineering education sufficient to meet most immediate needs.

Pressures are Accumulating

But if engineering education is not an immediate cost problem, it is one where many pressures are accumulating which suggest serious financial concern for the future unless more income is provided for its operation. Engineering education is tending to lengthen, especially to expect more students to continue into advanced graduate work for the master's, a specialized, or a doctorate degree. Engineering education is becoming more and more complicated, more and more highly specialized. This means more instructors with more varied educational background and experience. I have just been reading, for example, about the desirable qualifications today of an engineer to specialize in industrial control mechanisms based upon the feedback principle. I was astounded by the educational implications of this statement. Engineering education requires larger, better equipped laboratories than ever before. And instructional salaries must be increased in order to meet the competition of both industrial and governmental demands for engineering personnel.

All of these factors mean more expenditures. If we are to have the quality engineering education our society today needs and demands, then more income must be made available.

Where is the additional income to be found? For the public institution it must be obtained, first of all, from increased state appropriations. On the whole, the record of state support of higher education is a good one. The real tests are still ahead. State appropriations are supplemented by income from student charges, federal government research contracts, and even private benefactions. All of these must be employed by the public institutions in various ways in order to provide the income all higher educational programs must have, including the income essential to the further development of engineering education.

For the private institution the sources of available income are student charges, endowment, government contracts, and private benefactions for current operations. Student charges twice the levels which obtained in 1940 do no more than reflect the changes in price levels which have occurred in the past twelve years. On the whole, moreover, ability to pay for higher education is more widely distributed in our society today than ever before. There is still a need to provide assistance to the promising student of impecunious condition, but here too the current situation is reassuring even if not entirely satisfactory. The usefulness of endowment is by no means passed, and benefactors willing to make substantial one-time gifts, whether they be individual or corporate, must be encouraged to provide capital for future support. Most private institutions, moreover, need new physical facilities. For the moment, the requirements are for capital plant modernization rather than expansion. The instructional facilities of many institu-

tions are obsolete in terms of present-day educational needs. They must be replaced by much more modern classroom and laboratory buildings.

Government contracts have been extremely helpful in providing improved research facilities and in building up the research activities which are the base of much engineering education. The dangers are that some institutions have gone so far in rendering services to the federal government that they have almost forgotten their primary educational obligations, including their students. Moreover, institutions must continue to insist upon adequate allowances for indirect research costs if they are not to find research support a financial embarrassment. But no institution should ever become so completely dependent upon federal support as to jeopardize its financial future or its educational freedom.

Finally, there are various sources of private benefaction interested in providing income for current operations. Our colleges and universities of all types are only beginning to realize the potentialities of alumni funds. New foundations have sprung up all over the country, and many of these may well be interested in the support of various programs of higher education. As I have said before, corporation philanthropy is potentially a great new source of available income, and engineering education is peculiarly equipped to make an effective appeal for such assistance.

I should like to hope especially that the various professional engineering societies will maintain a keen interest in the financial well-being of engineering education. It is not enough to be concerned with educational quality, with desirable standards of professional competence and of institutional performance. This interest must be coupled with a constant endeavor to help meet the income needs which make educational quality possible.

No Reason to Despair

I see no reason to despair of the financial future of higher education in general, or of engineering education in particular. I am convinced that the American public can afford the kind of higher education which it wants. If our society wants low-cost, low-quality higher education, that is what we shall have. If our society wants high-cost, high-quality higher education, it will translate that desire into practical means of realization.

I have been told by the dean of one school of social work that this country is today spending 15 billion dollars a year through all public and private channels for welfare purposes, from old-age assistance and pensions to general relief and allied activities, including the operating deficit of hospitals. This is a gigantic sum. All our educational service from kindergarten through the Ph.D., public and private, spends only about half as much. Which in the long-run will contribute the most to the material and spiritual well-being of American society—these welfare, or these educational outlays?

But, if the American public is to want improved educational services, they must understand the needs, financial and otherwise, of our educational institutions and of our various educational programs. Here is the great challenge to the educational administrators and to professional groups today. What are they doing to demonstrate the essential income requirements of our educational effort in this country? When they have made their case, effectively and conclusively, they will find the necessary funds. This is still the promise of our society, and the hope for the future well-being of higher education.

The following five papers were presented at the ASEE–ECPD Conference in Chicago, September 5, 1952 in connection with the Centennial of Engineering. J. H. Lampe, Vice President of ASEE and Dean of Engineering, North Carolina State College presided. *Theme:* "1920–1950. What Are Contemporary Demands on the Engineering Curricula?"

What Are Contemporary Demands on Engineering Curricula?

Electrical Engineering

By W. L. EVERITT

Dean of Engineering, University of Illinois

Recent discussions of engineering education have focussed their attention on problems common to all engineers. This emphasis has led many to recommend that engineering should be taught as a unified program with no differentiation along technical lines. Others feel that any differentiation should be along functional lines, such as research, sales, operation, management, etc.

The word "specialization" has almost come to be an epithet with an emotional rather than a specific meaning, like the word "communism." Too often it is used to apply to what the other fellow is doing, which we don't like, while we insist our own specific attention to a particular area is "Giving examples to illustrate broad fundamentals."

Nevertheless, whether we call them specializations or not, curricula are overwhelmingly organized on the basis of technical divisions, many of which include optional subdivisions such as communication and power. The setup of this panel indicates that it might be fruitful for us to consider, as a group, the objectives of the major technical divisions, what has been happening during the past three decades, and where we are going.

The commodity of the electrical engineer, electricity, is of little direct use to man. Except as an unpleasant or serious shock, it cannot be observed by any of the physical senses. In this it differs from the products of the civil engineer, such as bridges, roads, and other structures, or the products of the mechanical engineer, such as automobiles, steam engines, and refrigerating and heating systems. Its study requires emphasis on imagination, understanding of classical and modern physics, and mathematical analysis. Electrical systems provide means for the transfer from one point to another of energy which is supplied initially in some other form, such as mechanical or chemical, and used finally also in some other form as mechanical, heat, or light. The energy may be transmitted primarily for the purpose of doing work, i.e., supplementing man's muscles, or for the purpose of transmitting information or making calculations or decisions, thus supplementing man's senses and brain power.

Electrical engineering has had a dramatic extension of its domain during the three decades under consideration. In 1920, almost all the attention was devoted to the problems of the generation, distribution, and utilization of power. During most of the period since that date, the power field has had a continual economic expansion. Engineering graduates have been in demand, and generally in short supply. The industrial advances have been made largely in size and efficiency; relatively few new devices or principles have appeared. The analytical changes of importance to curricula have been primarily in the area of network analysis, such as the use of symmetrical components, matrices, and tensors; in the extension of the two reactance method for analysis of

machines; in the use of electrical models or analyzers for the solution of complex problems such as stability; and in an integrated approach to electromechanical systems.

New Concepts and Applications

The dramatic increase in new concepts and applications in electrical engineering has occurred in the field of the collection, processing, and utilization of information. This development has found application in both the power and the communication industries. In this area, electricity has unique advantages. The development has taken place around the technology now called electronics. In passing, it might be mentioned that because information can be handled by devices which control small amounts of power, and because young technical devices, like young animals, are usually small, newly discovered physical principles find their most immediate applications in communication, using this term in a broad sense.

Information necessarily involves continual change; it is only through change that intelligence can be identified. Power systems, on the other hand, change slowly and less frequently. In the circuits of information systems, two alternative approaches have been developed to determine how they respond to rapid changes. One method is to analyze them on a transient basis such as by the use of differential equations; the other is to study their performance over wide frequency ranges. The two methods are tied together by the mathematical concepts of Fourier, LaPlace, and Heaviside.

As a result of these needs, increasing attention has been paid throughout this period to circuit phenomena, including various aspects of network synthesis, i.e., the design of circuits to transmit the signals required.

Circuits deal primarily with conduction currents—the guiding of electrical energy by solid conductors. With the invention of the vacuum tube, two new concepts commanded attention. One was the set of principles involved in convection currents, i.e., the transmission of electricity by electrons moving in vacua or in tenuous gases. Out of this developed the areas of electron dynamics and electron optics, a combination of mechanics and electric and magnetic fields. The electrons obey the Newtonian mechanics as modified by relativity, but the forces are due to electric fields, including the effect of the electron charges, and to motion in magnetic fields.

Equally important, the vacuum tube introduced new concepts of control impedance in circuitry. This type of active element required a new approach. The concept of control, when linear and continuous, makes the amplification of the complex signals possible. If the control is non-linear it introduces the principle of modulation, whereby signals can be shifted from one part of the frequency spectrum to another, so that a common medium can simultaneously carry many messages.

With the development of radio, attention was again focused on the electromagnetic field concepts of Maxwell, one of the most fundamental of all contributions. But these concepts require, for their full understanding, the relatively difficult mathematical language of vector analysis. Maxwell's equations, previously offered only to graduate students, have been made available quite generally to undergraduates, at least in communication options. Displacement currents took their place along side conduction and convection currents as important means for the transfer of electrical energy. Electromagnetic wave phenomena, both in free space and guided by wires and tubes, received more attention.

I cannot take time to cover the whole impact of this new thinking in what we now call "electronics." I include "servomechanisms" in the general field of electronics because its concepts are identical, although its mechanisms may or may not differ. Suffice it to say that we now use electronics not only to extend our sense organs in space and range, but also to

supplement our brain power. Electronic devices can be designed to think, in the sense that they can make decisions on the basis of a comparison between data which are picked up from physical situations of all kinds and transformed into electrical signals. After making such comparisons and decisions, they can also give and execute orders. Furthermore, they can compute, either as an exercise given them by human beings, or in the process of making their own decisions.

Modern industry is based on the supplanting of human labor by machines. Electronics contributes greatly to this end because it more and more provides the sense organs, nervous system, and brain-power for the control of the routine operations.

Effect of New Developments

What is the effect of these new developments on curricula? For one thing, they lead to justifiable skepticism of a program which treats all engineers alike. Such a treatment would almost certainly tend to freeze programs into more rigid patterns. The concepts of electronics include a wide range of fundamentals interrelated one with the other. In the early 1920's many electrical engineering professors, especially department heads, insisted vigorously that rotating machines taught fundamentals, while radio, which was to develop into electronics, was a specialized application. In institutions where electrical curricula were kept uniform, the teaching of electronics was delayed for years. But some of us were allowed to develop elective courses and options in which these new ideas, now recognized as most fundamental, were taught. If you are to have stimulating teachers, you must allow them to study and work with new ideas, even if the new idea is a recognition that Maxwell's equations are more basic than Ohm's law and that the vacuum tube is as important as the motor. They will also want to teach these new ideas to their students. If such new ideas are automatically labeled specialization and restricted to the graduate program, stimulation in undergraduate teaching will be lost.

The expansion of fundamental ideas has caused a progressive elimination of the "how" in favor of the "why." The modern electrical graduate is told little about the way things are done in industry; this he must learn in the particular company he joins after graduation. He is not instructed in "hardware" or shop processes.

In the teaching process the student is more important than the teacher, and the teacher is more important than his subject. The time has passed when we can have a da Vinci who takes all knowledge as his province. Research requires concentration in particular areas. If we are to have good teaching, professors must teach what they themselves are studying. This means that we will have to continue generally our branches of engineering. On the other hand, a special group of teachers, with a common purpose of unifying physical concepts in a wide variety of fields, will also find this a stimulating study, and so may provide an integrated program of great value. I doubt that this can become the general pattern, but we should watch these experiments with sympathetic interest and adopt the lessons which they will teach.

Science consists of asking nature for the reply to questions properly put. Science obtains new knowledge from nature. Engineering, on the other hand, consists in the solving of useful problems. Problems usually originate with men, and the recognition of the existence of a problem is an important step in its solution. The solution, in turn, is sought because of its utility.

As engineering teachers we are trying to teach our students how to recognize and solve *hard* problems. The only way to do this is to have our students solve such problems. This is substantially the essence of the "case" method recommended by many including the ASEE Committee on the Improvement of Teaching. An in-

dividual problem necessarily revolves around a particular situation. The situation may involve many concepts, but usually some area will predominate. The student must have an appreciable background in at least one area before he can tackle these hard problems. In electrical engineering we are interested in situations where electrical power or signals are of primary importance in the solution of the problem. If we teach our students how to solve hard problems in this area, experience has shown they can change over and solve hard problems in other fields, engineering or otherwise. It is important that in cultivating a particular field we emphasize to them that their training can be transferred, that the problems they will meet in life will always contain new elements.

Technical Areas

For the future, I see three particular *technical* areas which may need to be integrated into our electrical curricula. They are:

1. Biological and psychological subjects
2. Modern physics, particularly quantum theory
3. Statistics

Many of the new electrical systems find a counterpart in biological systems. For example, the theory of servomechanisms explains many operations in the animal world. Communication systems frequently begin and end with human beings. Many of the decisions on the physical details of a television system had to be based on experimental psychological studies of the nature of vision. If the electrical engineer is to work in these areas he will have to learn their language.

New developments will continue to draw on physics. Modern physics has increasing importance in such devices as gas-tubes and transistors. Our students will need to have this foundation for the electrical engineering of the future.

Information theory, noise, and radio propagation require the mathematical approach of statistics, a subject not generally stressed in engineering education. A place must be found for it.

Since problems of social and humanistic development are common to all engineers, they are being omitted in this discussion, although their importance is recognized. They must always be taken into account in planning any engineering curriculum. The big question will always be: How shall we make the best use of a student's time in preparing him for his profession and as a citizen?

Centennial Issues of the Journal of Engineering Education

The December and January issues of the JOURNAL OF ENGINEERING EDUCATION contain papers which were presented at the Centennial of Engineering in Chicago in September. Extra copies of these issues can be obtained for $1.00 per copy by writing to the American Society for Engineering Education, Northwestern University, Evanston, Ill.

What Are Contemporary Demands on the Engineering Curricula?

Civil Engineering

By HAROLD E. WESSMAN

Dean of Engineering, University of Washington

What are the contemporary demands on civil engineering curricula? Have our civil engineering teachers recognized these demands in setting the pattern of formal education for the civil engineers of today and tomorrow? Are significant changes needed? These are the questions which concern us today.

Thirty-two years ago, in 1920 to be exact, I was just beginning my civil engineering studies in the second year of the course at the University of Illinois. I had been attracted to this great engineering college by the name of Milo S. Ketchum, known to me at that time only as the co-author of a surveying book which had helped me in my early survey work in northern Illinois. I did not know then of Dean Ketchum's contributions to structural engineering nor did I have reason to know how fortunate was my selection of school.

Now, in 1952, as I look backward over the years spent in getting my formal education and the subsequent years of professional practice, teaching, and administration, I realize the tremendous influence exerted upon me and many of my contemporaries by a score of men at the University of Illinois. Fortunate indeed are those who sat in the classrooms of Hardy Cross, Westergaard, Talbot, Shedd, Wiley, Rayner, and other great teachers.

Many of you in the audience today at this Centennial Celebration honoring engineers and their achievements can look back and pay corresponding tribute to great teachers of civil engineering in other fine engineering schools. As we direct the attention of hosts of people throughout the world to the role of the engineer in making America what it is today, let us not forget that the fountainhead of our engineering achievements is an assembly of engineering teachers who have evolved an American pattern of education which in my opinion is unsurpassed throughout the world, a pattern which is characterized by flexibility, informality, and creative stimulus.

As I look over this audience and see many fine civil engineering teachers, as I recall many others who are with us only in spirit, and then, as I think of the thousands of students who have sat in the classrooms of these men and who have gone out and helped to remold America, I can reach no other conclusion but that civil engineering teachers are discharging in an outstanding way their responsibilities in engineering education. Possibly we could do better, but on the other hand, anyone who has travelled and lived in other parts of the world, knows that we could do infinitely worse.

Major Accomplishments

Let us recount briefly the demands of practice during the past thirty years by focusing the spotlight on a few major accomplishments. But let us keep in mind that these achievements are only symbolic of hundreds of lesser achievements, all of which bear eloquent testimony to the

vision and creativeness of civil engineers.

This has been the era of the Empire State Skyscraper, the Holland Tunnel, the Pennsylvania Turnpike, the Tennessee Valley Authority, the Mississippi River Control, the Golden Gate Suspension Bridge, the Grand Coulee Dam, the Columbia Basin Reclamation. This is the period of sewage treatment in Chicago on an unprecedented scale, of huge slum clearance and housing developments in New York City. This is the period marked by the greatest war in the world's history, a war which was won primarily by the technology of America. It was a war characterized by the construction of vast American military bases from the far-flung islands of the South Pacific to the frozen wastes of Alaska, from the burning sands of North Africa to the towering mountains of West China.

This is also the period of through highways, of airports mushrooming over the length and breadth of our country, of the birth of structural aluminum, the erection of huge industrial plants, and the development of photogrammetry. In all of these, the civil engineer has played a leading role. Has he been weighed in the balance and found wanting? Have there been serious deficiencies in his education?

I was talking to a leading consulting civil engineer in New York City only a few weeks ago. He was the head of a firm employing several hundred engineers. I told him that I had just returned from the convention of the American Society for Engineering Education in Dartmouth and that we were reviewing again the educational pattern of engineers as is our mission in this Society. He said, "Why do you need to change civil engineering education? Look at the men that you have graduated during these past years." He cited a number of names of men who were doing outstanding work with his organization and went on to say, "There is nothing radically wrong with our American system of engineering education when it turns out such men."

When we study the nature of the work of the civil engineer today, we find that even though projects have increased in magnitude, the job functions are essentially the same today as they were 30 years ago. Civil engineers still have to design bridges and buildings, build highways great and small, develop water supplies, dispose of sewage, plan municipal developments, erect dams and reclaim the land. These are the things which they have done for years and will continue to do. But that does not mean that the products of their work in directing the forces and materials of Nature for the use and convenience of man are the same today as they were 30 years ago. Nor does it follow that our technical education, our teaching, has remained static even though the fundamental tools of mathematics and mechanics are the same. Due to research and study we have new knowledge about old things; we have new materials and processes; we have better methods of analysis; we know more about the properties of materials and the behavior of structural elements. We know more about the forces of Nature. These advances in knowledge are reflected in constant changes in the content of civil engineering courses, even though the titles of courses are the same, which is as it should be because of the nature of civil engineering.

Civil engineering education has always been alive and responsive to the demands of the profession and to the results of its research. One test of the vitality of an educational program is found in the answer to the question: "Does the program of engineering education and the associated college research lead and inspire practice?" If one studies the history and development of civil engineering education objectively and honestly in the light of professional practice, the answer to this question is unequivocally, "Yes." In fact, one of the reasons why this is so is that most of the research in civil engineering is either concentrated in the colleges or is handled by public agencies which are

guided by advisory boards on which college teachers are represented. There is relatively little private industrial research such as is found in the electrical and mechanical fields.

Educational Content

Let us look briefly at various branches of civil engineering and see whether educational content has changed in the past few years and whether the work of college teachers has influenced and dictated practice. Recall if you will, the work of Talbot at Illinois, Shank at Ohio State, Turneaure at Wisconsin, Lyse at Lehigh and Gilkey at Iowa State in the field of reinforced concrete. In fact, I find myself embarrassed at this point because there are many people in this audience who have contributed to a better knowledge of the nature of concrete materials and the behavior of reinforced concrete structures and whose work has resulted not only in better teaching but in better design practice. They should all be named.

In the field of structural theory, it is only sufficient to mention the name of Hardy Cross. But again, I must apologize to a host of contemporaries, many of whom came under the influence of Hardy Cross, and all of whom have contributed something in their own right to structural theory and design. The tremendous impact of Hardy Cross, however, upon civil engineering teaching and practice is particularly manifest when we note that his methods of analysis of structures are not only being taught in practically every school in the country but are being used in practically every structural design office in every large city in this country.

In hydraulics or if you prefer, in fluid mechanics, added vitality has been brought to the teaching and to the laboratory training of civil engineering students primarily because of the influence of a group of Freeman Scholars, some of whom were graduate students under Professor Cross. These men went abroad in the twenties and combined that which was best in European laboratory practice with their own American background. As a result, we have developed the finest hydraulic laboratories in the world, laboratories in which theory and experiment have gone hand in hand to give us new knowledge about the behavior of water and other fluids, knowledge which has been reflected in teaching and in practice.

Think if you will of foundation engineering which, even though glorified by the semi-science of soil mechanics, probably involves more of that intangible known as engineering judgment than any other branch of civil engineering. The names of Terzaghi and Casagrande come to mind immediately but again as I look over this audience, I see a number of engineering teachers who have contributed new knowledge in their own right even though their initial stimulus came from the Harvard Graduate School. They would be the first to admit that our knowledge now is not exact, but nevertheless is better than that which we had thirty years ago. The work of these teachers has changed both college courses and design practice in foundations.

The problems of water supply and sewage disposal are always with us. Is the content of these courses the same as it was 30 years ago? Do we still teach wheelbarrow methodology in construction engineering? How about highways and airstrips? Look at the *Proceedings of the Highway Research Board*—in fact, scan the Journals of all of the technical societies associated with the branches of civil engineering. There you will find ample evidence that the research of civil engineering educators, research which is inevitably reflected in the courses which they teach, is something which has gone far beyond the confines of the Ivory Tower in leading and in influencing the practice of professional engineers in America.

It would be a simple matter to list the names of 200 outstanding contemporary teachers in civil engineering who have played a part in keeping civil engineering

education alive and responsive to the changing needs of our civilization. Some of them will be found on the list of recipients of the Lamme Award and the Westinghouse Award for significant contributions to engineering education. In fact, most of the Westinghouse Awards to young outstanding teachers have been to civil engineering teachers. The citations accompanying these Awards bear eloquent witness to the collective impact upon engineering of only a few of my Honor Roll of 200 names.

What of the future of civil engineering education? Some say we need more science, in particular more mathematics and more physics, in order to give our students a better grounding in basic principles. Perhaps we should have more mathematics and more physics for some civil engineers enrolled in graduate study in certain special areas. Should we have it for all undergraduate students? I believe not. In fact, there is no room for more science courses as such in the four-year undergraduate curriculum. Let me hasten to add that this is not an argument for a five-year undergraduate curriculum.

There is a danger lest in the attempt to make better scientists out of our engineering graduates we make them poorer engineers. Hardy Cross in his book, "Engineers and Ivory Towers," states: "The systematized, formalized procedure called science, which is supposed to lead inevitably to unquestionable results, contrasts with the flexible independent creative instinct which produces art"—and which motivates the true engineer. Science points toward a unique solution, whereas an engineering problem usually has many solutions which must be compared in the light of related economic, social, legal, yes, even psychological factors. Of course the engineer should use the scientific tools at his disposal, use them efficiently and well. But I question whether a course in differential equations for all civil engineering undergraduates, a course taught by mathematicians, will help them appreciably in solving their engineering problems.

Five Great Problems

There are at least five great problems confronting the civil engineer of the future. The first and probably the worst is traffic congestion in our large cities. The second is municipal rehabilitation, of which slum clearance is only a part. All one needs to do is travel in the four-mile-wide belt around the heart of this great city of Chicago to know what I mean. The third is adequate water resources. The fourth is industrial pollution. The fifth is highway reconstruction and safety. These are not alone the problems of the civil engineer, but nevertheless the civil engineer has a primary responsibility in their solution and I doubt if more mathematics and more physics in the college curriculum will turn out engineers better able to cope with them.

One of the most difficult tasks confronting the teacher is the stimulation of the creative instinct in the engineering student. One way to accomplish this is to incorporate elements of project design and development wherever possible in our engineering courses rather than rely on the use of isolated problems. The project method encourages vision and imagination. But let no one delude himself into thinking that the project method is a recent discovery. I can name five of my teachers who used it in their courses at the University of Illinois 30 years ago. Outstanding in particular were the projects of Professor Shedd in his bridge design courses.

There is no question however, but what a more widespread use of the project method is desirable. Our students must learn, for example, that the design of a highway involves many other factors than the design of the sub-grade and the paving and the bridges and the culverts. We design arterial highways so that traffic can travel more quickly between cities but these same through highways bring more traffic quickly into the hearts of cities with the result that the streets in the business districts have now reached the

saturation point and are choked beyond capacity.

Civil engineers are faced more and more with the necessity of a broad approach to a problem. Too often have we seen one problem solved at the expense of creating a worse one. It is negligence of the worst sort to design and erect a modern industrial plant without provision for the safe disposal of its waste products.

Can we do the right kind of an educational job in a four-year undergraduate curriculum, with additional years of study for only those who desire graduate degrees? A man may become a good structural engineer or sanitary engineer or highway engineer after completing a four-year civil engineering curriculum, but the evidence seems to indicate that he would be a better engineer in any one of these branches if he had a fifth year of specialized graduate study. In fact, many civil engineering students would profit by a fifth-year curriculum in industrial management. But this is not an argument for a five-year course for all engineers. I believe that the recommendations of the 1940 ASEE Committee on Aims and Scope of Engineering Education relative to the four-year undergraduate program for all, and graduate study for those best qualified, are fundamentally sound. These same recommendations were endorsed by the 1944 ASEE Committee on Engineering Education after the war. They were further supported by the 1944 Committee on Engineering Education of the American Society of Civil Engineers.

I do earnestly believe, however, that a larger percentage of civil engineering students should be induced to elect a fifth year of advanced study. However, let us not forget that the education of an engineer is never completed, not in five years or even ten years.

Some of these discussions over engineering education are like the early arguments between religious denominations. "We are the true sons of God, the real defenders of the faith. If you want to get to heaven, this is the road you must take," cries one sect.

"No, that is the sure road to hell" is the rejoinder from another group. "We will show you the path to salvation." We may thank God that a Christian spirit of tolerance and considerate judgment have in recent years brought not only religious groups but educational reformers closer together in recognizing that there is no one specific prescription to achieve our goal. We all want to give our young engineering students the best possible education, and if we keep our programs alive and responsive to the changing needs of society and the dictates of new knowledge, then by the same process of evolution which has characterized our development in the past we will continue to fulfill our mission.

Third Midwestern Conference on Fluid Mechanics

TIME: March 23, 24, 25, 1953.

PLACE: University of Minnesota, Minneapolis, Minnesota.

SUBJECT MATTER: All features of theoretical and applied fluid mechanics.

What Are Contemporary Demands on Engineering Curricula?

Mechanical Engineering

By NEIL P. BAILEY

Head of Mechanical Engineering Department, Rensselaer Polytechnic Institute

The genius of the mechanical engineering profession has been in the past and must continue in the future to be focused primarily on two things. The first is the release of energy and the production of power from fuels. The second is the conception, manufacture and distribution of machines to utilize this energy. The present standards of Western Civilization stem from the release from human toil made possible by the use of this power. The energy is derived from 2 gallons per person per day of petroleum and 32 pounds per person per day of coal. The power is dependent upon the ingenuity to make and distribute devices that enable this energy to perform routine tasks. There are known requirements for the continued success of this entire operation. It is necessary to maintain a sound economic system under which these benefits do not price themselves out of the reach of those who work to bring them about. Also, the resulting gains must be used to increase the nation's accomplishments and not to promote its indolence.

The period of 1920 to 1950 was marked by an ever-widening vision of the mission of mechanical engineers. Such things as the national resources of materials and purchasing habits of consumers became a part of a designer's consideration. The reduction of manufacturing and distribution costs assumed a significance beyond that of merely affecting selling prices. A National depression and a World War during this period did much to make mechanical engineers conscious of the social significance of their work. Enthusiasm for this trend in thinking has led to the addition of many Arts College type courses to mechanical engineering curricula. Students still view such courses as being a separate requirement distinct from their engineering education. In general the students are probably correct. The teaching profession has yet to find ways of making such courses into a natural part of an engineering training.

The period of 1920 to 1950 saw rapid advances in mechanical engineering technology. Entire areas such as heat transfer and system control that were no more than arts in 1920 became well developed fields of science by 1950. In other fields such as heat power, application changes came so rapidly that the entire teaching emphasis had to be changed. The advances in all technical areas demanded a higher proficiency in mathematics and a wider knowledge of physical science. That this occurred during a period of decreasing emphasis on mathematics in American secondary schools magnified its significance.

Curriculum Crowding

The simultaneous widening and intensifying of demands on mechanical engineering education have posed serious problems of curriculum crowding. Various methods of solution have been proposed. To

merely add a year to the four-year curriculum is a tempting one. But at a time when this Nation faces a serious world situation with a deficient supply of talented young men and when each youth is faced with from one to three years in the military service of his Country, such a simple solution as a universal five-year curriculum is not the answer.

A second quick solution is being also urged on college administrators. It amounts to practically the elimination of departmental senior year courses as they now exist. The proponents of this course of action believe these senior year departmental courses to represent an unjustifiable attempt at specialization in a four-year curriculum. Those who know what actually lies behind rather specialized sounding course titles evaluate these courses at their real worth. In a modern mechanical engineering curriculum these senior courses carry a major share of the training in engineering methods of working. In these courses students learn something of the art of bringing all of their knowledge, logic and experience to bear on a situation and learn to discipline their minds to hours of sustained logical thinking. It is here that they learn that engineering situations have multiple instead of single solutions and that science can aid but never replace sound judgment. This second solution to the curriculum crowding is unacceptable to mechanical engineering teaching departments who must stand responsible before the world for the performance of their graduates.

The broadening and intensifying of mechanical engineering education by a procedure of careful re-evaluation and selection must be followed, but it must proceed more rapidly in the immediate future. To be successful, such a process of re-evaluation must be carried out against a background of sound premises as a guide. To begin with, such a curriculum must be designed with the idea that each student is aiming at professional competence as a mechanical engineer. There is much talk of a watered down program designed for those students who do not aim to follow the profession but who desire merely a mechanical engineering background. It would be possible to give such students a general background of physical science in a reduced number of courses but a background in mechanical engineering is, by definition, the ability to think as a mechanical engineer. If a more painless way of achieving this were known it would be used on all mechanical engineers.

In the second place such a program must be designed with the idea in mind that each student will at some time in his professional career supervise others. Since supervision is the act of multiplying a person's usefulness by having him guide others, he first must possess abilities worth multiplying. Next, he must be taught to view life in a broad way and to comprehend and consider other human beings before he deserves the right to influence their lives.

In the third place a balanced curriculum must clearly recognize the great difference between the mere possession of factual knowledge and the ability to apply it to useful purposes. The art of logical thinking cannot be developed without accurate facts to think about. Inventive ingenuity and analytical skill, to be productive, must feed on accurate facts but they can both be foundered by an excessive emphasis on the accumulation of a knowledge of facts. The present extent and rate of growth of technical knowledge in all the areas of mechanical engineering must be admitted to be beyond the mastery of any single individual and far beyond the capacity of students. A balanced mechanical engineering curriculum cannot, therefore, be one that covers all related areas of technology. Rather, it must be one which teaches students to gather facts, analyze situations and evaluate solutions in each general area of mechanical engineering.

Over-Specialization

Over-specialization of a curriculum can appear in various forms. It can refer to

an unbalance in time distribution between the three areas of power development, design and manufacture, and economic, political, and human aspects of production and distribution. It can appear as an over-emphasis on the accumulation of factual material in any field with a corresponding deficiency of time for a student to learn to reason from these facts. With the present enthusiasm to make more of a scientist out of an engineer it could also take the form of over-specialization in a knowledge of mathematics and science far beyond the training in applying it. It can even occur locally in a curriculum in such a form as the concentration of all mathematics in the first two years, long before its uses can be comprehended.

Even after it is admitted that a mechanical engineering curriculum is to be constituted only of organized course sequences in each of major areas, the situation is far from being resolved. At the moment and by virtue of its historical seniority, power development with its ramifications is usually over-specialized in most curricula. It is over-specialized in two ways. Not only does it receive more than its share of the available curriculum time but also far too much of a student's effort goes into a familiarization with the physical facts of the subject and not nearly enough time in gaining experience in solving engineering situations of a comprehensive nature. This over-crowding of courses by a knowledge of physical facts reflects a combination of an inertia against discarding obsolete information, an eagerness to add new information and a reluctance to reorganize the working concepts and methods of presentation.

The second major area of mechanical engineering, the processes of conception design and manufacture of devices, is usually so dispersed around a campus as to lose much of its possible effectiveness for students. They study at one time or another many details that are involved in evolving a product to fill a need but only in retrospect, if at all, are they able to put the pieces together and see the sequence of steps involved. This situation is rationalized by insisting that after all, designing is an art that can be mastered only be practice after graduation.

Between 1920 and 1940 the design aspects of such courses as power plant design, combustion engine design, and heating design disappeared. By 1950 only machine design remained and it had become restricted to the mechanics of the metal parts of machines. Simultaneously, separate and often completely independent courses in shop processes, manufacturing methods, and production procedures came into being. Now all products must be conceived for their function, be proportioned for their use and be manufactured for their market, and these three things are not independent considerations. Mechanical designers must project their minds into new situations and simultaneously weigh all of these factors. Regardless of the organizational changes that become involved, educators must find ways to develop design as a broad process of mechanical engineering. The output of talented graduates with a developed interest and ability in design is far below the minimum needs of industry and well below the potentialities of the American youth entering mechanical engineering departments.

As early as 1920 there was serious concern because engineers were not making contributions to the social adjustments demanded by mass production in manufacturing. With reduced production costs eliminating skilled trades and in some cases actually driving up distribution costs, there was and still is fear that the machine may thus defeat itself. In searching for reasons for the ineffectiveness of mechanical engineers in this area it was first decided that engineers did not write or speak well enough. It was concluded that their knowledge of costs, purchasing and distribution was inadequate. There was a growing conviction that engineering thinking did not include enough understanding of practical everyday relations with people in industry and business. Between

then and 1950 the curriculum time aimed at this area of instruction was increased to as much as one-fifth of the total. The results, to date, are far from what were hoped for. Instead of courses adapted to fit into engineering curricula in a manner to be of direct value to engineers, the year 1950 found these courses more nearly corresponding to an Arts College minor and diverging further and further from the original objective. Neither the mechanical engineering teaching departments nor engineers in industry are favorably impressed by the results realized to date because the original aim has not been achieved.

Demand for Graduate Study

The steady increase in technical knowledge between 1920 and 1950 produced a greater and greater demand for graduate study, particularly at the master's level. It also resulted in a marked change in the nature of graduate study. The amount of formal course work increased as the individual project work decreased. This has continued until in 1950 many schools no longer require even a thesis in a masters program.

This same trend can also be seen in the undergraduate program. The undergraduate thesis disappeared, and the number of project courses decreased as the percentage of formal subject matter courses became greater. Irrespective of the merits or faults of subject matter courses and old project courses this represents a trend away from the emphasis on the training of the individual student toward an emphasis on subject matter mastered. This, coupled with a steady decrease in laboratory and supervised design and problem periods, should be reviewed thoughtfully. At a time when there is a recognized need for more originality, creativeness and individual ingenuity among mechanical engineers it would be sad indeed to be turning out a generation of students who could analyze and criticize ideas with great skill if only someone else would have the ideas.

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ANNUAL MEETING

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What are Contemporary Demands on the Engineering Curricula?

Chemical Engineering

By GEO. GRANGER BROWN

Dean of Engineering, University of Michigan

Engineering is the "Art and Science by which properties of matter and sources of power in nature are used by man in structures, machines and manufactured products."

Art is "skill or ingenuity in the adaption of things in the natural world to the uses of human life."

Science is the "accumulated and accepted knowledge which has been systematized and formulated with reference to general laws."

Putting these definitions together, it is clear that engineering combines the skill and ingenuity with a competent knowledge of the general laws which summarize our knowledge of matter and energy and their applications to structures, machines and products.

When Chemical Engineering curricula came into being about fifty years ago they were primarily industrial chemistry with a few courses in mechanical engineering added to give them an engineering flavor. At that time the practitioners were generally graduates of chemistry curricula and many such held that the best preparation for Chemical Engineering was graduate work in Chemistry as there was no particular knowledge concerning the processing of materials which had been accumulated or formulated with reference to general laws. The Chemical Engineer, having no science of his own, therefore, relied almost entirely upon the Science of Chemistry and the Art of the Mechanical Engineer. This was a successful combination and the Chemical Engineer made important contributions in solving new problems created by the first World War and the rapid development of the chemical, petroleum and other process industries immediately thereafter.

Perhaps because of their roots in chemistry, Chemical Engineers are avid experimentalists and acquire extensive data on their operations. Imbued with the scientific spirit, they correlated these data on similar operations in different industries on the basis of the Unit Operations as suggested by A. D. Little in his report to the Massachusetts Institute of Technology in 1915:

> "Any chemical process, on whatever scale conducted, may be resolved into a coordinate series of what may be termed "Unit Operations" as pulverizing, drying, roasting, crystallizing, filtering, evaporating, etc. The number of these basic unit operations is not large and relatively few of them are involved in any particular process. The complexity of Chemical Engineering results from the variety of conditions as to temperature pressures, etc., under which the unit operations must be carried out in different processes, and from the limitations as to materials of construction and design of apparatus imposed by the physical and chemical character of the substances being treated."

Armed with these correlations, the Chemical Engineer was able to solve the problems of processing new materials

without any previous experience in such processing. The only new information required was a limited knowledge of the properties of the material to be treated. Frequently even these had to be estimated due to the limited amount of the material available for experiment. This ability was dramatically demonstrated by the chemical engineers of the du Pont Company in the design, construction and operation of the nuclear reactors and plutonium processing plants at Hanford in 1943. As the science of the unit operations developed from 1920 to 1950, it gradually displaced the old technology courses which aimed to acquaint the student with industrial practice in particular industries, which were generally treated according to the chemist's classification of organic and inorganic technology. The quantitative more general study of the unit operations gave the student more power to solve new problems in new industries.

Undergoing Simplification

The more complete our knowledge the simpler is the framework which can be used for systematizing the accumulated facts. The unit operations themselves are undergoing simplification. Absorption, stripping and fractionation are now treated as one operation known as vapor-liquid transfer but applied for different purposes; and vapor-liquid transfer is further being closely associated with the corresponding liquid-liquid and liquid-solid transfer operations. Fluid mechanics is being studied and may become a common fundamental science covering all fluid, mass and energy transfer operations such as fluid flow, mixing, mass transfer and heat transfer.

On the other hand, as more knowledge is accumulated and accepted, the teacher is frequently persuaded that he must have more time to acquaint the student with this additional knowledge. This is perhaps particularly true in Chemical Engineering because of its additional background in Chemistry as well as Physics. But this point of view overlooks the most important characteristic of Science, that is, the systematizing and formulation of knowledge with reference to general laws. As science advances, our general laws become more reliable and with a more complete understanding of the basic general laws a much better understanding can be given the student in less time if the curriculum emphasizes the general laws of science and their use in arriving at solutions to engineering problems rather than attempting to cover the accumulated and accepted knowledge that is available. The latter approach tends to develop an ability to solve only those problems which have been solved, while the former tends to develop an ability to solve those problems which must be solved. Was it Einstein who said, "Scientists are those people who solve the problems which they can solve, and engineers are the people who solve the problems which have to be solved"?

The decisions in design, construction, management and operation usually based on incomplete data, but made on the basis of judgment, ingenuity and experience generally guided by an appreciation of the fundamental general laws of science are the highest form of engineering combining Art and Science.

There are two exacting demands on contemporary chemical engineering curricula in the presentation of science. The first is to emphasize and develop an understanding of the basic general principles which consititute true science and to forego the teacher's desire for complete presentation of his knowledge. This must be reserved for post-graduate courses in special fields. A firm foundation in the general laws of science is also an excellent background for graduate study as well as for the practice of engineering. Second, because the student is to be prepared for engineering practice in the future twenty to thirty years, and because the frontiers of science today are the accepted basic principles of engineering practice tomorrow, the student should be exposed to the most modern thinking in

physics and chemistry, and not simply to those well established principles which he might be called upon to use today. The college or university is the best opportunity afforded the student to become acquainted with these modern concepts.

The standard freshman or sophomore course in Physics frequently divided into the five divisions of Mechanics, Heat, Sound, Light and Electricity, and following the plan of instruction which has been in vogue since the Spanish War generally fails to meet either of these demands. It may have the opposite of the desired effect by emphasizing the differences in the various subdivisions.

Technology presented as descriptions of and current industrial practice has no place in a curriculum in chemical engineering except as examples in the application of general principles. Such descriptive technology taught in school is almost certain to be obsolete by the time the student reaches a responsible position in practice, and current industrial practice is best learned on the job.

Requires Practice

The Art of Engineering requires practice and the student should be given some practice at least in the last year in the recognition and definition as well as the solving of engineering problems. Such problems should be presented in general terms so the student must first resolve and define the problem and then arrive at a reasonable solution with incomplete and frequently confusing data. The willingness to tackle such problems must be developed in the student, and this seems to require that the assigned problems have some factor or slant which has not been discussed or explained in class or in the text; otherwise the student feels abused and resentful if called upon to do some original thinking. The complaint that "we never had that before," or "you never told us that" may be an indication that the proper type of problem has been assigned.

This ability to take the responsibility for a solution based on incomplete data and thereby create a new process or a new design is the major outstanding characteristic of the engineer. It can be acquired or developed as witness the number of individuals trained as scientists in Chemistry, Physics or Mathematics who become successful engineers by acquiring this skill or ingenuity and experience. But it is necessary to be certain that the graduate engineer has at least a certain minimum of this art by requiring him to demonstrate his ingenuity in some creative project before graduation; otherwise he may be a mere scientist equipped with tools but unable to use them.

There are many other collateral demands in addition to the general scientific background and experience in creative work such as the design of a new process which must be satisfied if the curriculum is to be wholly adequate. The development as well as the expression of ideas requires the effective use of language of some kind. When we say a man thinks in English or in German or in Mathematics, we mean exactly that. Language is a tool for thinking as well as for expression, and the engineer uses at least three languages for these purposes: English or his native tongue, Mathematics to an ever increasing degree, and graphical presentation or drawing. To be effective the use of language must be precise and easy. This requires constant and careful use. Therefore, the student must always be required to use, and use correctly, these three languages in his professional course. It will not do to delegate the responsibility for the correct use of English to the English Department, or for Mathematics to the Mathematics Department, or for Drawing to the Drawing Department and then ignore these matters in the professional courses any more than it would be considered satisfactory to ignore the principles of science developed in the basic science courses in teaching the professional engineering subjects in the senior year. Such practices undo all the good work of

the English, Mathematics, Drawing and Science Departments and give the student the idea that having completed these courses, he now has no further use for them and instead will concentrate on his professional work.

Teamwork is Essential

Practically no engineering graduate fails in industry because of technical inadequacy, but many fail of realizing their potential success because of inability to write effective reports, to present their ideas effectively before a Board, or to work smoothly with their associates. This last requirement leads to another important demand on modern chemical engineering curricula, to train and develop the student to work well with his associates. This cannot be done if he is always required to do individual work throughout his entire college program. Any number of courses in psychology will accomplish practically nothing compared with actual experience in working with others. Perhaps this is a major advantage in the cooperative curricula if the student learns to work with others during his apprenticeship in industry. But much can be done in requiring students to work in squads in many courses in the normal full-time program. The senior laboratory and design courses are excellent opportunities for this experience which also has advantages in developing technical ingenuity.

The requirement for admission as a candidate to the doctorate in Chemical Engineering at Michigan has included for many years the preparation of a satisfactory engineering report which includes the design for a new process. This is known as the twenty-one day problem because of the time allowed. One of these involved the economics of recovering the solvent from extracted bean meal. The successful graduate students and the faculty had come to believe that such a process was not economical. In the course of time this doctoral problem became a senior project in which the seniors work in groups of three as separate firms of consulting engineers. One resourceful group of seniors went into the laboratory, obtained some data, and established the fact that it was economical to recover the solvent if the dried unextracted beans were used to absorb the solvent vapor.

Furthermore, it must be remembered that the faculty are teaching men, human beings, and not simply technical subjects or worse yet simply certain textbooks; and that these men must have some human interest other than their technical problems. Industry and the world is made up of human beings and the engineer is a much better engineer if he has fully developed human interests. These are generally best developed by voluntary activities on the part of the individual in participating in extra-curricular activities such as debate, sports, editorial work, and in courses in the humanities such as history, literature, philosophy and music. The student must be given an opportunity and encouragement to develop and pursue these interests. But this should always be on a voluntary basis and such courses should be handled as electives. Otherwise, they are frequently regarded as simply additional hurdles to be overcome.

Instruction Must Be Streamlined

To meet these contemporary demands, the undergraduate instruction must be streamlined. We must recognize the advances that have been made and are being made in all fields and continually revise our presentations to eliminate all that which is not absolutely essential.

Some months ago the college of Pharmacy was celebrating its seventy-fifth anniversary and in looking ahead to the future years, there was considerable discussion that the curriculum would have to be lengthened to at least five and probably to six or seven years to include all of the new facts and information being developed in the field of pharmacy and the necessary humanities to make a well rounded citizen. President Hatcher, who is a recognized scholar in Literature and History, was then called upon to close

the meeting. He commented that 150 years ago the entire offering of courses at Harvard College, including a list of the text books used, was printed on one and one-half pages of a small book-size pamphlet while at the present time a large modern university offers 4000 courses. To take advantage of all of these offerings one individual would attend classes for three hundred years. When he studied history a three hour course might cover five hundred years or more of history but now such courses cover fifty years and we might look forward to the time when a fifteen weks course in history would cover an equal length of time. He suggested that this difficulty was created by allowing the teachers of graduate students to establish the courses available for undergraduates and he advised the pharmacists that they should determine how much time in their four year curriculum should be devoted to history and then put in that course only those things which they would not dare let a pharmacist escape from their institution without knowing.

I believe President Hatcher has expressed the fundamental demand upon all contemporary undergraduate curricula.

National Science Foundation Appoints Paul E. Klopsteg as Associate Director

Dr. Paul E. Klopsteg, Assistant Director for Mathematical, Physical and Engineering Sciences of the National Science Foundation, has been appointed to the new position of Associate Director of the Foundation. Dr. Raymond J. Seeger, program director for physical sciences, has been appointed acting Assistant Director for Mathematical, Physical and Engineering Sciences.

In his new capacity, Dr. Klopsteg will be responsible for assisting the Director and the Deputy Director of the Foundation in following closely the development of relationships with universities and with other Federal agencies; he will also handle special assignments of importance to the scientific programs of the National Science Foundation. Dr. Klopsteg, who came to the Foundation in November 1951, was Professor of Applied Science and Director of Research of the Northwestern Technological Institute, Evanston, Illinois, and is on leave of absence from Northwestern.

What Are the Contemporary Demands on Engineering Curricula?

Mining and Metallurgical Engineering

By C. L. WILSON

Dean of Missouri School of Mines

At the turn of the century the education of the mining engineer was considered to have reached its highest level when the student went to the Bergakademie in Freiberg, Germany, the Royal School of Mines in London, or L'Ecole des Mines in Paris. The School of Mines of Columbia University was the first division of a university in the United States established specifically as a School of Mines. It was officially opened on November 15, 1864. Other Schools of Mines were established in Missouri, Colorado, Michigan, South Dakota, Montana, and New Mexico on separate campuses. Mining Engineering curricula and the B.S. degree in Mining Enginering were offered at numerous universities throughout the country during the latter quarter of the 19th century and the first part of the 20th century. At mid-century the trend has changed and now students from many countries come to the United States for instruction in mining. Universities in Canada, too, offer instruction in mining which is as excellent as that of the United States or any other country.

Previous to 1920 curricula in Mining Engineering covered the entire field of what is known today as the mineral industries. A student graduating in Mining Engineering would just about as commonly go to a smelter as to a mine. His work in mining would include geological exploration as well as mining exploitation. At a smelter he might start as an analytical chemist or assayer and then advance to either smelting or concentrating operations. His curriculum in Mining Engineering had prepared him more or less adequately for any of these fields of work. The mining engineer, because of the probability of going to remote sections of this country and to many foreign countries, had to have some knowledge of surveying and Civil Engineering, Mechanical Engineering, especially steam power, and some Electrical Engineering as well as Chemistry, Mineralogy and Geology. Good Mining Engineering curricula, even before the beginning of the century, contained courses in Mechanics, Hydraulics, Thermodynamics, and Steam Power. Fundamental courses such as Mathematics, Physics, Chemistry and Drawing were taught in the first two years.

While the Mining Engineering curriculum, up to about World War I, was considered adequate for the smelting or extractive metallurgist, the importance of physical metallurgy began to grow so rapidly following World War I that specialization was introduced and curricula and degrees in Metallurgical Engineering were offered in many schools and colleges. The primary distinction was that the Mining Engineering curriculum contained more courses in Geology and the Metallurgical Engineering curriculum more courses in Physics and Chemistry. The growth of the petroleum industry resulted in curricula in Petroleum Engineering and the importance of the geologist brought about curricula in Geological Engineering.

With the depletion of high grade ores, the art of mineral dressing became a necessity and while mineral dressing is rarely a separate curriculum in our colleges today, it is a respected option or branch of Metallurgical Engineering. One more field should be mentioned and that is Ceramics or Ceramic Engineering which is the application of scientific principles to the manufacture of products like brick, glass and porcelain from nonmetallic minerals usually at high temperatures. Ceramics is one of the oldest arts known to man.

Advances in Technology

From the preceding evolution it can be seen that before 1920 Mining Engineering prepared the student, with a remarkable degree of success, to apply his education to engineering activities in mining, metallurgy, geology, mineral dressing and ceramics. In the last quarter century new discoveries and applications of fundamental sciences have resulted in miraculous advances in technology and these advances, together with the pressure of competition requiring low cost production, have compelled industry to seek engineers with more specialized training. While mineral industries today generally require the services of mechanical engineers, electrical engineers, and civil (structural) engineers in their fundamental operations, they need engineers who are trained in specialized areas of what now is frequently given the comprehensive appellation mineral engineering.

The mining engineer today deals primarily with the selection and design of mining methods and the proper equipment for mining exploitation. His work demands a knowledge of structural geology and map interpretation. He must be acquainted with the principles of prospecting and mine development. Succesful underground mine development requires ventilation and atmospheric control as well as blasting, timbering, transportation and hoisting. Operations will not be successful unless principles of cost evaluation and management are correctly applied.

Metallurgical Engineering deals fundamentally with the extraction of metals from their ores and shaping them for utilization. This field itself has become highly specialized although fortunately not with separate academic degrees or even options. The curicula however are arranged with electives so that the student may specialize in mineral dressing, extractive metallurgy, or physical metallurgy. Mineral dressing deals with the mechanical separation and concentration of the valuable minerals from those not presently desired. One important type of mineral dressing known as flotation has made such intelligent application of the principals of physical, organic and colloid chemistry that good curricula now contain courses in all of these fundamental subjects. Extractive metallurgy deals mainly with smelting or leaching and these operations require fundamental courses in chemical thermodynamics and electrochemistry. Physical metallurgy is a study of the structure and constitution of metals and alloys and their relation to their physical, chemical and mechanical properties. One of the most important fields of knowledge needed in this branch is the physics of the solid state. Because metals are relatively simple in their atomic structure, physical metallurgy has contributed much toward the knowledge of the physics of the solid state. Courses in x-ray analysis are becoming essential. The electron microscope and the x-ray spectrograph equipped even with Geiger counter are tools which illustrate how physical metallurgy is dependent upon basic modern science.

Petroleum engineering has likewise been subdivided into two distinct fields—petroleum production and petroleum refining. Petroleum refining is essentially a specialized field of chemical engineering. Petroleum production differs from mining engineering in that the end product is a liquid or gas instead of a solid and therefore quite different exploration and exploitation methods are required. The geology used in Petroleum Engineering must include not only structural geology

and stratigraphy but also paleontology and even micropaleontology. The science of geophysics finds widespread application in prospecting for oil and training in geophysics is becoming a requirement in Petroleum Engineering curricula. All of the above curricula are offspring of the original curriculum in Mining Engineering. The above curricula, where accredited by ECPD, may be assumed to conform to at least the minimum qualitative and quantitative criteria set forth by ECPD. They prepare engineers for the mineral industry which, like agriculture, is a basic industry upon which our present civilization is founded.

Demands Becoming Greater

The demands upon the mineral industry will become greater in the next half century than ever before. Mineral deposits, unlike agricultural products, cannot be replanted and it is logical to assume that they eventually will be depleted. Substitutes for materials now commonly used must be found. We can here express our confidence in the resourcefulness of youth. For example, my grandfather was constantly concerned about the reckless cutting down of hickory trees. Although a successful business man in his day, he could not imagine a satisfactory substitute for hickory in the manufacture of wagon wheels. Another example is found in the extended use of bromine. For many years the principal and adequate source of bromine was the brine wells of Michigan. When motorists began to demand high test gasoline in larger and larger quantities, the brine wells of Michigan could not supply enough bromine for the manufacture of all the tetraethyl lead required. No other source of bromine appeared available except ocean water. Today engineers are literally mining the ocean for its bromine. Our engineering curricula must continue to inculcate in our students this spirit of experimentation and discovery.

Most of the mineral deposits outcropping on the surface have been discovered by that historical character the prospector on his burro. Today the geologists must explore the earth's crusts to greater depths. Such exploration will require more and more use of complicated scientific apparatus whose utilization will demand an understanding of modern physics. Geology, formerly a descriptive and qualitative study, must now become quantitative to an advanced degree. Methods of mining to greater depths will demand engineering skill far beyond that employed in present day methods. Metallurgical Engineering must cope with the problem of treating lower grade ores and of extracting such more common metals as titanium and zirconium from their minerals and aluminum from clay. In addition of course we must reconcile ourselves to less wasteful and more intelligent use of metals and materials which are now common and we must insure more efficient secondary recovery after their use has been completed.

Firm Foundations in Fundamentals Necessary

Contemporary demands on curricula in mining and metallurgical engineering place upon us the vital responsibility to make it possible for the engineer who graduates today to meet these changing and complex problems twenty-five or more years from today. These demands emphasize the necessity of building firm foundations in the students' knowledge of fundamental scientific and engineering courses. They require a lessening of emphasis upon courses which are largely descriptive in nature. Courses in mining methods, smelting methods, other metallurgical and mineral dressing operations, and ceramic processes must of necessity contain some descriptions of current procedures but these must be reduced to a minimum and more emphasis must be placed upon design, application and experimentation. Such contemporary demands are not difficult to meet because the principal requirements are not college buildings, laboratories and new and ex-

pensive equipment although of course adequate physical plant will always be necessary in modern engineering colleges. The principal requirement is the teacher himself who can skillfully guide the student toward that only kind of successful education which is self education. The teacher must guide the student to sources of knowledge and then inspire him with confidence and enthusiasm. Attendance at meetings of engineering and scientific societies, and particularly at meetings of the American Society for Engineering Education, will provide the teacher himself with good guidance. By affiliation and active participation in local, sectional, and annual meetings the teacher will make it possible for ASEE to help them meet the contemporary demands on engineering curricula.

Learning or Teaching Aids?

In the September issue of the Journal of Engineering Education the Committee on Teaching Aids issued a last call for devices to be submitted for review and possible inclusion in the forthcoming CATALOGUE OF TEACHING AIDS. A similar appeal has been made in the past to industry through important technical periodicals.

The material submitted to the Committee as a result of these pleas indicates that a wealth of high caliber devices and ideas are available from engineering college teaching staffs. It has also led to the conclusion that such devices can be classified and defined as follows:

1. LEARNING AID—A device that creates within the student a desire to recognize or pose a problem and which further enables him to understand the fundamentals underlying the solution.
2. TEACHING AID—A device that aids or effects the explanation of rather narrow areas of factual knowledge. The Committee is reviewing both types.

It has been made painfully clear to the reviewing groups in civil, electrical, mechanical, mechanics and mathematics that the colleges are the most fertile source of LEARNING AIDS. Unfortunately, engineering teachers appear to be extremely modest in offering devices for consideration by the reviewing committees. It is regretable that a personal contact cannot be made for all such devices but the committee must rely on the help of all ASEE members in ferretting out this material. The deadline is March 1. May we have your continued help?

Carl W. Muhlenbruch, Chairman
ASEE Committee on Teaching Aids
Northwestern Technological Institute
Evanston, Illinois

Orientation and Development of Junior Engineers*

By JOHN F. GORDON

Vice-President of General Motors Corporation

I am honored that your societies have invited me to come here tonight to speak upon the subject "Orientation and Development of Junior Engineers." With your permission, I would like to deviate slightly at times with some remarks of a more general nature because I feel that you may be more interested in objectives than in methods.

In General Motors, we regard engineering as a career of unparalleled opportunity for the young man leaving a technical college. It is a career of challenging assignments, of interesting problems, of pleasant working conditions. There is really no limitation on progress or financial compensation as evidenced by the fact that the Chairman of the Board of Directors, the President and about half of the Vice-Presidents also started their careers as engineers. They have progressed through the organization as Civil, Electrical or Mechanical Engineers into their present executive positions. Moving a little lower on the scale of corporation authority shows a remarkably high percentage of engineers in positions of great responsibility in the divisions as general managers, works managers, chief engineers, and plant managers. These facts assume even greater significance when it is realized that graduate engineers represent less than two percent of the employees and all of our men classified as engineering employees do not add up to five percent of the total.

There is no specific procedure in promotion which makes it particularly easy for the engineer to achieve such status. On the contrary, the promotion into important executive positions of engineering personnel is considered one of the major reasons contributing to the phenomenal growth of General Motors during the past twenty-five years, when product sales have been multiplied over seven times, net income increased three times and employees increased from 130,000 to 469,000.

We believe the results achieved in the corporation emphasize beyond any words that I might say tonight how importantly the various types of engineering science have contributed in men and products to the growth of one of the nation's great business enterprises.

We approach the future with confidence that the same form of progress will continue on an accelerated basis because the percentage of engineering personnel to other employees should continue to increase and show a correspondingly greater contribution to our corporate success. With this psychology in mind, it is only natural that we approach the employment and development of junior engineers with a complete realization of their potential worth to our future programs, even though we know that the true value of their training may require ten to twenty years for development into full significance. Today we hear a great deal about the shortage of engineers, and every effort is being made to attract graduates to in-

* Presented before the Engineers' Council for Professional Development in Chicago on Friday, September 5, 1952, in connection with the Centennial of Engineering.

dustrial employment. At the same time, much is being done to stimulate interest in the study of engineering among a larger number of high school students. Industrially, we are redoubling our efforts to make better use of experienced engineers to their full abilities by effectively using the engineers who are available and by filling the more routine type of technical positions with people having a limited background of training.

We know that a fair sized percentage of those who start the study of engineering do not finish. Some drop out for financial reasons; some are attracted by jobs offered to them before they graduate and some find they do not have sufficient interest or the necessary ability to continue this training. Some of these change their courses to other fields, such as business administration. I do not believe we should worry about this as a by-product of efforts to attract more high school graduates into the study of engineering, because a good percentage of such students will have gone far enough in their studies to learn the fundamentals of the engineering approach to problems and will find employment in which they can make valuable contributions. From a long range standpoint we need graduate engineers who can handle the problems of product design and development but we also need those who can apply the engineering approach to the problems of production, business administration, sales and human relations, even though they may not be graduate engineers.

Employment of Engineering Graduates

While I am talking about the present shortage of engineering talent, I think it is desirable to explain our method of determining the number of college graduates we need to employ each year. This is important in its effect on our program of development for these men after they reach employee status inasmuch as we desire neither too many nor too few in the organization. Too many can easily result in injustice to the employees promotion rate; too few can only result in inadequate rate of progress for the company. Each separate division and corporation staff activity is requested to analyze its fields of work and the demonstrated educational requirements for success in those fields in order to determine the educational courses from which graduates should be recruited. The field of engineering education comprised 86% of the group requested for recruitment in 1952. Consideration is also given to such other factors as retirements, normal turnover, and possible growth or expansion of the organization in arriving at the probable number of future opportunities in the various departments of the business. Also taken into account are such factors as the number of our own General Motors Institute students in training, those available for promotion from other non-collegiate personnel, and the average number of graduates who drop out during their first few years of employment. From the study of these statistical analyses, each division determines the number of new graduates to be employed. As a general guide it is suggested that each unit employ at least one graduate per year for each one thousand employees.

A similar approach is used in the determination of the number of General Motors Institute students to be sponsored by each division or staff group. In this instance the sponsoring unit must not only take into account a possible loss in graduates during their first years of employment after graduation but also some loss in students during the four or five years of collegiate training prior to graduation.

The Institute became a part of General Motors in 1924 and is now the focal point of our training activities for the entire corporation. The most important segments of its activities are the cooperative collegiate programs in mechanical engineering, industrial engineering and business administration. These programs were established because it was felt that a portion of the engineering talent needed by the corporation could be found among our own employees and effectively

trained in our own operations—particularly in the fields of automotive design and manufacturing. We have evolved a balanced program of training at the collegiate level within the organization and recruitment of graduates from other colleges whereby we capitalize to the maximum on our internal "know-how" but maintain full access to the variety of viewpoints and educational backgrounds developed at other colleges across the land. We feel justified in claiming that the program results in an industrial team of unusual strength and ability in both theory and practice.

For example, in arriving at its quota of Institute students for its engineering department in 1950–51, a typical division of General Motors, made the following analysis:

Needs:

Number of exempt personnel in the department	50
Number of yearly losses plus number needed for expansion	3
Number of new graduates needed each year	3

Sources:

Number to be promoted from non-collegiate ranks	0
Number to be recruited from colleges	2
Number of G.M. Institute graduates needed	1

After adjusting for a possible student and graduate loss it was estimated that the number of G.M.I. students would be two per year. A similar analysis was made for each of the other departments and the division arrived at a figure of 14 Institute students in engineering and business administration needed each year in addition to 8 graduates from other colleges.

We believe this is a factual and realistic approach to the troublesome problem of arriving at the number of graduates needed in our industry. It gives primary emphasis to the places where there are opportunities. It reduces over-recruitment. It is fair to employer and employee alike.

You may be interested in the following comparison between the number of General Motors Institute and other engineering graduates employed during the last four years:

Year	G.M.I.	Other Engineering College Graduates
1948	242	171
1949	350	282
1950	301	275
1951	200	339
4 year totals	1093	1067

You will note that we have averaged something over 500 new graduate hires per year for these four years with as many as 632 entering our organization in a single year. Each of those men was employed with full expectation that the opportunity for a career awaited him in the corporation, if he could demonstrate the ability to justify that career. The integration of such a group would be a major problem if it were attempted on a centralized basis, but it is not accomplished that way. With the decentralization of operations which is the keystone of our management policy, the orientation and development program is in the hands of divisional management at Chevrolet or Cadillac, at Electromotive or Delco-Remy, or one of the many other divisions doing business under the General Motors banner. As is true in all other phases of our business, however, the individual divisions expect and receive direction and advice from the central office staff, executives, and the Personnel Policy Committee of the corporation to assist them in their program with college graduates. This advice is not based on the premise that college graduates should be established as a separate group nor given preferential treatment. Like all other employees, it is the graduate's responsibility to develop himself, prove his worth and show whatever potential he has for greater responsibility.

Emphasize Need for Competent Engineering

In General Motors we recognize that the operating success of the corporation

depends primarily upon a continuous program of development and improvement in the major elements of facilities, products, and personnel. It goes without saying that improvements in our facilities and products require an extensive program of research and development under the guidance of engineers and scientists. Each change in plant layout, each improvement in manufacturing methods, each revision in equipment involves engineering problems. Almost every phase of the business except sales and legal guidance emphasizes the need for competent engineering.

We also recognize that the young engineers we employ come to us with a good fundamental understanding of engineering theory and some background in its application. In a sense they are the partially processed personnel material out of which will come many of our ranking engineers and executives of the future. Thus it is our responsibility to establish procedures which will assist the graduate in his introduction to industrial employment and at the same time maintain him in an environment which will stimulate and promote his growth. Provided with these helps, it is still required of the individual employee that he take the initiative in self-development through use of the opportunities that are presented to him.

In meeting the requirements I have outlined, the majority of our operating divisions have set up orientation training programs for the college graduates on their rolls. While these programs are tailored in content and length to match the situations in different divisions, generally they are designed to acquaint the new employee with the products and practices of the plant, give him a brief acquaintanceship with the work of its principal departments, and help him to learn what is expected of him in an industrial position by observation of the work of other engineers in the organization. These programs usually consist of a series of practical work assignments in the departments or sections of the Divisions related to the field of work for which the graduate was employed. For example, a junior engineer might be given brief assignments for observation in manufacturing, production engineering, accounting, sales, traffic and purchasing in addition to his major work assignments in product design and development. This gives him a limited amount of information about the business, but primarily helps him to understand the interrelation of engineering activities with other activities in the organization. It is also helpful to employee and management in proper placement of the new man in his first post-training work assignment.

Professional Development Encouraged

An essential element of all in-plant training programs is frequent contact between executives of the management group and the trainees, as this provides the opportunity for our young engineers to acquire some of the practical knowledge that these older men have accumulated during their years in the division. Even more important in our opinion—it helps the youngster to know that his efforts are being recognized, that his capabilities are being evaluated, and his professional code is being improved by these contacts. We try to impress upon the young engineer the fact that his technical educational opportunities did not end when he received his degree. He is urged to participate in the meetings of local technical societies, in community affairs and plant activities of various kinds, always with the objective of his personal and professional development through the medium of his own activities.

Even the most talented group of young engineers would be at a loss if we did not provide them with the physical facilities needed in their professional efforts. We are justly proud of the excellent buildings and equipment in use by our divisional engineering departments. From them have come many of the major improvements of modern transportation, such as the high compression engines, the light weight two cycle diesel engines, automatic transmissions, all steel bodies, ethyl

gasoline, diesel locomotives and jet engines. Our research laboratories and product proving grounds have been of invaluable assistance to the chemists, metallurgists and engineers with the ability to study and evaluate some of the fundamental factors of combustion, lubrication and power development.

Yet, we are not satisfied. Construction work is now in progress, as it has been for three years, on a new Technical Center on the outskirts of Detroit. When completed, it will house staff activities in research, engineering, styling and process development in a group of buildings that provide an entirely new concept of industrial research to meet tomorrow's needs. Our young engineers are well supplied with facilities which will aid them in making professional progress, and will be even more adequately supplied in future years.

I have spent some time in discussing the technical phases of our development program for young engineers with full knowledge that any orientation program aimed only at engineering competence would be inadequate. Consequently, I would like to direct attention to the "human engineering" factors in the same program and thus leave with you some of the psychology of General Motors in dealing with its employees.

It should be obvious that any large corporation is an organization of many people in which no single individual is apt to reach his personal objective without the voluntary cooperation and assistance of his associates. Experience has demonstrated many times that the degree of cooperation is determined by the personality factor more than anything else. Modern industrial progress depends on teamwork to such a degree that the graduate must be able to submerge his individuality to a considerable extent in order to become an effective member of that team. As a member of the team, he must be capable of making his own contributions, yet be flexible enough to change his own ideas as new thoughts are presented to him by other members of the group. Few indeed are the industrial positions wherein an engineer can work as a "lone wolf." If he honestly wishes to progress, he must be able to adapt himself to the organization in a whole-hearted manner. He must learn to work with people until his responsibilities increase to such an extent that the major requirement is for people to work with him.

Personality Development

Much of the executive effort going into our development program aims at the goal of influencing and correcting personality and professional characteristics which, if left unchecked, could and probably would have an adverse influence on the individual's future progress in the organization. This is a difficult task but the results justify a great deal of effort.

Actually, we believe that the essential components of a successful career in our corporation can be reduced to just three requirements on the part of the young graduate engineer:

(1) The graduate's native abilities such as health, energy, imagination, intelligence, initiative and comparable characteristics.

(2) The graduate's ability to understand and use the known laws of the arts and sciences—as you have taught him to do in his formal education.

(3) The graduate's understanding and appreciation for the so-called "unwritten laws" of the practice of engineering by which his own efforts are integrated into the larger field of industrial production.

Believing as we do regarding the essential components of a successful career, our "human engineering orientation" attempts to assist the development of each of these components within the limits of our abilities. We recognize our limitations in seeking much improvement in native abilities except as we utilize existing qualities to their best advantage. However, the requirement of high level native ability is sufficiently important that

we give it careful consideration in the selection of our students at General Motors Institute and in the screening prior to recruitment of all other college graduates. Perhaps I should say that we value above average physical and mental characteristics in combination with professional ability very highly, and make every effort to determine, in advance, that our new engineers will have an abundance of native ability before they enter the corporation as engineering employees.

With reference to the second requirement for success—the graduate's ability to understand and use the known laws of the arts and sciences—we have no quarrel with existing formal education in technical colleges. The graduates who join us each year are well instructed in the fundamentals of theory but lack background in its application except to a very limited extent. This feeling is engendered to a large degree by our extensive experience in cooperative educational programs involving thousands of men in our organization. We place a high value on the extensive background experience gained by cooperative students during their years as undergraduates, and would like to suggest greater efforts on the part of colleges to secure comparable opportunities for their students through summer employment or similar industrial contacts.

It would be relatively easy to speak at great length on the third requirement for success which covers the unwritten laws or the professional code of engineering practice and behavior because I am very familiar with the subject. It is only in the last few years that I have not been devoting all of my time to the practice of engineering. I mention these years of professional experience in order to place proper emphasis on this statement—very few of the many engineers that I have known, failed to progress due to insufficient technical ability. Many have been found lacking in personality or personal characteristics and their lack of development classed as a professional failure. The price of these failures is large at any time, but it grows greater when the man is allowed to move along in the organization for some time before his shortcomings are evident. We try to avoid such mistakes throughout our development program by frequent appraisal of each individual in the program by expert counseling aimed at correction and by continuous association with experienced engineers. If all of these methods fail to produce the desired results, there is always the possibility of transfer into other activities of lesser requirements.

My talk has covered some of the things we believe are important in providing opportunity for *self development* to the engineers in General Motors. This concept of an individual "developing himself" as opposed to "being developed" by the company recognizes that no one is foreordained to become an executive although we strive to achieve that result over a period of years.

Cooperation with College Faculty Sought

We aspire to a closer relationship and a better understanding between college faculty members and the men of our industry who have responsibility for carrying out the program I have just outlined. To achieve this result in General Motors we are giving added emphasis to our educational relations activities with engineering colleges. This program provides for periodic conferences of technical educators with our engineers in order that we can become better acquainted and develop a more complete understanding of our mutual aims. We are preparing to furnish qualified industrial speakers on engineering topics and to the use of other media for making available engineering and manufacturing data which is suitable for supplementary use by colleges. We are studying ways and means of providing some of our products for instructional and testing purposes in the schools. We are interested in every possible improvement in our program to make it successful and practical because we place great faith in the ability of these young men to assume responsibility for a large part of the engineering, industrial and economic leadership of tomorrow.

Can Engineering Graduates Man a Company?

By E. G. BAILEY

Chairman of the Board, Bailey Meter Company

My answer to the question, "Can engineering graduates man a company?" is yes, because they are now doing it very creditably in many cases. The important point is: How can each one of us study the many cases at hand and draw some helpful conclusions regarding college curricula, selection of graduates, training, and promotion of engineers for the best interests of our industrial economy?

The success of a company is usually measured by its usefulness to mankind, its rate of growth, and its earnings. A good record in these respects is usually the result of team work on the part of management to evaluate properly the needs in a given field of products or services, and to accomplish results through invention, development, production methods, sales, services, and finance.

The August 30 issue of *Business Week* gives some interesting data regarding ten companies which show a marked contrast from the average of industry generally over the same period. Eight of these ten companies show an average increase in invested capital of 42 per cent per year from 1929 to 1951, while the invested capital of industry generally increased at the rate of 2.8 per cent per year over the same period.

The net profits of the eight companies averaged 11.2 per cent of invested capital in 1929 and 9.6 per cent of the increased capital of 1951. Some of these data are given in the accompanying table. It would be interesting to study the management policies of these companies with respect to our topic.

Statistics alone are sometimes misleading. During a depression the earnings and growth may be poor even though the management is good. Contrariwise, during an inflationary "easy prosperity" like the present, very poor management of a company may not be evident, even to the stockholder.

Now, let us review some average statistical data from the Engineers Joint Council survey of 1946 on "Employer Practice Regarding Engineering Graduates." In this summary 125 companies, with a total of 2,020,000 total employees, reported 38,000 engineers employed. This is 1.8 per cent of the total number of employees, or one engineer for each 55 employees. In some industries the engineers were 6 per cent of all employees and in others as low as 0.3 per cent. In some groups the engineer executives comprised 50 per cent of all executives of the same rank, and in others as low as 13 per cent with an average of 28 per cent. The anticipated increased need of engineers was 6 per cent per year of the engineers then employed, or one engineer for each 1000 employees.

From this survey a median of the 14 companies within the machinery group has been selected to represent a typically average industrial company. This we shall call "X-Machine Company," employing a total of 7000 people and having gross sales of about $80,000,000 per year. This is a fairly representative figure of about $12,000 output per employee.

This company employs 133 engineers, 28 of whom, which is 21 per cent, are in executive and top management positions. The total number of executives and upper managers is 64, of whom 44 per cent are engineers.

This industry group said they needed 8 per cent additional engineers per year, or, for "X-Machine Company," 11 engineering graduates each year, or 1½ engineers per 1000 employees.

DATA FROM *Business Week*
August 30, 1952
(page 58)

	Invested Capital				Net Profits	
			Average Increase per Year			
	Millions of Dollars			Per Cent of 1929	Millions of Dollars	
	1929	1951			1929	1951
Abbott Laboratories	3.6	67.9	2.9	81.	0.6	10.4
Aluminum, Ltd.	50.2	443.5	17.8	36.	2.4	28.8
American Cyanamid	41.3	274.9	10.6	25.	2.3	34.8
B. F. Goodrich	162.6	239.8	3.5	2.	7.4	34.7
Humble Oil	216.4	916.5	31.9	15.	32.5	109.5
International Business Machines	33.7	318.3	12.9	38.	7.4	27.9
Minneapolis-Honeywell	4.9	80.0	3.4	70.	1.4	9.3
Minnesota Mining	4.8	106.6	4.6	96.	1.5	9.9
Monsanto Chemical	12.3	263.4	11.4	93.	1.1	23.5
Scott Paper	6.7	67.2	2.7	41.	0.9	10.9
Total	536.5	2778.1	101.8	19.	57.5	299.7
Per cent of invested capital					10.7	10.8
Total with omission of B. F. Goodrich and Humble Oil	157.5	1621.8	66.4	42.2	17.6	155.5
Per cent of invested capital					11.2	9.6

High Percentage of Engineers Desirable

In my opinion, a company in this kind of engineering business should have about 80 per cent of its executives with engineering training. The reason for this is that an engineering education is eminently helpful as a background for factual approach to the problems encountered in industry, based upon engineering processes, products, and services. Many companies do not now have this high percentage of engineering graduates but they should gradually build up to a higher and more adequate proportion.

Whether a company is increasing its proportion of engineers or continuing on a normal basis, it should employ a certain number of new graduates each year. I mean each and every year whether business is good or bad. One of the mistakes which many companies make is to take on fewer graduates when times are a little slack. This leaves a gap in the supply of properly trained men a few years later when they will need more men than they will then have. For instance, we all short-changed the engineering graduates during the depression of the thirties, and subsequently we needed them badly during World War II. In 1949 all of the available engineering graduates were not given proper jobs and, as a result, a shortage is being experienced today.

Hiring the proper quota of new graduates is not enough. They should be enrolled in proper training courses and given every opportunity to learn the business and develop into positions of responsibility and leadership. To help industry do a better job in such training is the purpose of Mr. Montieth's activities in ECPD during the past few years.

I will not go into detail regarding the training course itself but I would like to express some opinions about the problems of the later advancement of these trained

engineers through the upper echelons of the company.

Engineering graduates, while they have received the correct basic engineering training, are human beings with differences in temperaments and abilities in both technical and administrative fields. To successfully man a company with engineers requires considerable development of the men over and above what they are when they receive their diplomas.

The usual organization chart is drawn to show the line of authority running down from the top. It should also be looked upon as the path for advancement from the bottom upward toward the top position of president.

Upon completion of the training course, the engineer is usually assigned to a department in a particular division and then, for a time at least, left to the mercy of whomever happens to be his immediate boss.

I think the education department should have a continuing interest with some cooperative authority to make sure that the individual is treated fairly with reasonable assurance that his advancement will be the greatest of which he is capable.

At some point in this upward progress, each man should become known personally to the top management so that he will be properly evaluated and given every possible chance for deserved promotion insofar as justified by relative competitive abilities.

Engineers for Top Jobs

Now a word about engineers for top jobs in comparison with men trained in the legal, financial, or "business administration" fields.

The top executives should form a strong team, proficient in finance, sales, production, and especially in engineering, research and development, and invention. Each and every one should know the product in every detail, and especially from the customers' viewpoint.

The customer is all-important and a full knowledge of his needs and future trends should be known not only by the sales department but also by the production and engineering departments, and especially by the president. As the products and services of industry are largely within the engineering field, it is best that all members of this management team should be engineers or men with an engineering background who have advanced on their own initiative into fields of finance, sales, and management.

Some lawyers and bankers have become very engineering minded and have used good judgment in making major decisions regarding engineering, research, and development problems when they have confidence in and give opportunities to the engineers in the team to analyze and evaluate the problems properly.

The degree of success of a company rests almost solely with the president or top executive officer. It is he who selects the vice presidents and top staff and establishes the policies and methods for coordinating the different divisions and departments.

Many of the most successful companies, large, small, and intermediate in size, have done very well in the training and advancement of engineering graduates throughout their organizations up to and including the presidency.

Those that have not done so well in this respect simply do not grow and prosper. They either limp along, or fail, or are absorbed by others. When a successful company makes some changes that are not for the best, it may be several years before the mistakes are fully realized, because a going concern can drift for some time upon the reputation and momentum of the past.

Many of us can relate cases where improvements should be made, but it is best to study factual data of successful companies for the benefit of all. The engineering profession should present to the top executives of American Industry illustrative factual data relating to the successful use of engineers in such an effective manner that all will strive to improve their present methods for selecting, training, and advancing engineering graduates within their respective companies.

Manpower Utilization and National Security*

By ARTHUR S. ADAMS
President, American Council on Education

The steadily increasing demand for trained personnel by the military services and by the productive economy of the country emphasizes the urgency of the need for finding effective and equitable solutions to the problems of manpower utilization which Mr. Brown has identified so clearly.

In dealing with these problems, however, our concern with total overall allocation of manpower should not blind us to the overriding importance of the attitudes, concerns and interests of the individuals who comprise that total.

The principle that each of us has an obligation to serve our country is certainly the fundamental basis of our free democracy. Indeed, we need to recognize more clearly than we now seem to do that we, each of us, can expect to continue to enjoy the blessings of liberty only in the measure that we accept the commensurate and personal responsibility which freedom so surely entails.

Likewise, there can be no dispute on the principle that each person should serve where he can serve best, in the light of his abilities and limitations, his talents and his training and that such service should be up to the full potential of his capacity.

Yet in all of these considerations, as we give attention to the maximum contribution of each individual, we should—indeed we must—recognize the aggregate of contributions of all individuals in relation to the total needs of the country. Our build-up in military strength in which science and engineering play such vital roles is assuredly of great importance, but I believe we can all agree that it is only a part of our total national problem. Of equal importance are our efforts to develop connections of mutual understanding and support with the other nations of the world.

Perhaps our most powerful weapon is our effort to provide full access to the facts about our way of life rather than to ring down an Iron Curtain between ourselves and other nations. In this effort to promote understanding between other nations and ourselves, men and women trained in the social sciences and the humanities have vital and significant parts to play. The fact that they have these parts to play does not in the least minimize the essentiality of the contributions to be made by engineers and the scientists. We need skilled people in all of the disciplines. We must recognize that there is a shortage of manpower and womanpower for *all* of these necessary activities.

In a speech in this city last spring, Mr. Robert L. Clark, Director of the Office of Human Resources, of the National Security Resources Board, made this point with particular effectiveness by detailing the current scarcities for earth-scientists, geologists, geophysicists, meteorologists, oceanographers, geographers, soil-conservationists and agronomists, and then went on to make the significant point that while "adequate military manpower plus scientific, technological, and managerial supremacy will give us maximum military strength, it must be borne in mind that military force has the ultimate object of achieving a change of behavior of an enemy only after reasonable means of persuasion have

* A statement by the Engineering Manpower Commission of Engineers Joint Council.

failed." As he put it "an intelligent view of our national security requires that we have the same kind of concern with the characteristics and behavior of people in all parts of the globe that we so obviously have with the characteristics and behavior of matter."

To achieve an understanding knowledge of other people requires clearly that we have an adequate supply of people who are expert in all of the factors of life of those people. Certainly we should know as much as possible about our principal adversary, Russia. Yet in the last four years only thirteen Americans have taken Ph.D. degrees in Russian language according to the reports of the U. S. Office of Education. It seems abundantly clear to me that in framing our overall manpower policy, we must take account not only of the obvious needs of technology and science but of the equally impressive, although not so obvious, needs in other areas of knowledge.

It was on the basis of this sort of thought that the present Selective Service policy concerning college deferments was based. In these days when, as Dorothy Thompson has said, "man's means of communication so far outstrips his ability to communicate" we must take provident action to be sure that we have qualified people in as great a number as possible in all of the departments and subjects of human knowledge. We cannot be sure but that at some future time, it may be vital to our security to have the specialized knowledge of some few individuals who like the specialists in coral formation in World War II were able to do so much to push forward the campaign in the Pacific. To put it another way, we can never be sure that some type of specialized skill, not now considered especially important, may become critical in meeting a national need. Who would have argued in 1929, when Dr. E. O. Lawrence started his researches with the cyclotron at the University of California, that a nuclear scientist would be essential to our military defense in 1952?

Concept of the Individual is Important

In meeting these total needs I believe that we are sometimes blinded to the importance of individual hopes and aspirations by the sheer weight of numbers with which we have become concerned. We get to thinking of people as units with vocational tags attached. It is one thing to talk about the need for twenty, thirty or forty thousand engineers; it is quite another to think about one young man who wants to become an engineer. I feel that we must constantly keep in mind that we are dealing with individual people and that what they want to do in order to make their contribution is important.

As a person trained in engineering and also as one who has participated in both World Wars I and II, I cannot subscribe to the notion that a plan for compulsory exemption from service for any group is in the national interest. In my opinion, it is not even in the interest of that group no matter how important the services of those who form the group may be toward meeting our total need. For example, to refuse enrollment in the Reserve Officers Training Corps of scientific and engineering students would seem to me to be an invasion of the individual's freedom of action as a citizen. Now at the same time, I would hasten to say that if such an individual did enroll in the R.O.T.C. and subsequently entered upon active duty it would be only common sense for the military service of which he was a part to do its utmost to make full use of his special talents in assigning him to duty in which those talents could be fully used.

One further item on the R.O.T.C. to which Mr. Brown alluded. Both the Army and the Air Force are undertaking during the coming year experimental curriculum revisions by which branch and special designations for various components in the R.O.T.C. will be abandoned in favor of a general curriculum. Some of those especially interested in our current engineering shortage have expressed concern that this move will militate against the most effective assignment of these young men when they graduate insofar as utiliz-

ing their special training is concerned. In my opinion, this concern is not justified. I am informed by responsible officials of the Department of Defense that it is precisely to make better use of the individual's professional training that the change is being made.

In many of our institutions we have had units of the R.O.T.C. in, let us say, field artillery, coast artillery, infantry or other branches which offered the only opportunities for the enrollment of engineering students in the R.O.T.C. Once commissioned in a particular branch, a young R.O.T.C. officer found it difficult to transfer to a branch of the service to which his professional training was more germane. In the new plan each graduate of the R.O.T.C. will have an opportunity to indicate a preference for that branch of the service which he desires and for which he is best qualified. Moreover, it is my understanding that careful procedures are in prospect by which his indication of his preference will be reviewed by those competent to appraise his professional qualifications. It would therefore appear that the move of the Army and the Air Force to a general curriculum is a move in the direction of the better utilization of this individual's strength which I think we will all agree will lessen our present concerns with waste of engineering talent in the military service.

Supply of Engineering Graduates

It is interesting to me, and I hope it is to you, that on December 30, 1947, I participated in a symposium in this city at the annual meeting of the American Association for the Advancement of Science which had for its subject "Insuring Adequate Scientific Personnel." At that meeting it was reported by others that there was likely to be an over-supply of engineers by 1950 with certain engineering specialities having a much greater over-supply than others. It was further reported that the immediate attempt to train more scientists might do more harm than good because in the long run there is a danger of shortage of high quality scientists because of the then current over-crowded conditions in colleges and universities.

In my remarks at that symposium I offered an exactly contrary opinion. It seemed to me then as it does to me now that while it may be theoretically desirable from the standpoint of utilization of manpower to have the number of jobs exactly match the number of people trained for them, I considered it fortunate that changing conditions make precise planning in this area impossible. I see grave limitations in an education so restricted in outlook that it would provide adequate basis for only one type of occupation. "It seems to me axiomatic that education to be worthy of the name must do much more than to fit a person for a particular vocational slot in the social system. Our objective should be to determine and then to develop to the fullest possible extent the capacity and aptitudes of individual students. Unless the individual has greater resources than those demanded by any specific job he may undertake he lacks that adaptability to changing circumstances which is not merely the hallmark of the educated man but the margin of flexibility which permits our democratic society to progress."

Engineers Play Vital Role in Our Society

Today we know that the predictions of December 30, 1947 about an over-supply of engineers were incorrect. We do need more engineers and we need good engineers. The Engineering Manpower Commission is to be commended for its efforts to attract into the engineering profession young men and women qualified to profit from this type of education. This is indeed an important matter which is contributing with notable significance to a better appreciation by the American people of the vital role that engineers have in our society. In order that this appreciation may develop into a true public understanding there must be confidence that the case for engineering takes into account our total national needs together with full recognition of the importance of the individual.

Manpower Utilization and National Security *

A Statement by the Engineering Manpower Commission of Engineers Joint Council

By CAREY H. BROWN

Chairman, EJC Engineering Manpower Commission. Member ASME

Every citizen shares the universal obligation to serve his country. The type of service he can best render depends upon his abilities and limitations, his talents and training. For the best interests of the nation, each person should serve where he can serve best and up to the limit of his abilities and capacity. This concept demands service, not only in uniform, but also in those activities that must be maintained to support the national economy. Such activities include agriculture, defense, and other essential production, transportation, communications, medicine, education, government, and others, required in the national health, safety, and interest.

Today our nation faces an indefinite period of partial mobilization. In addition to a shortage of manpower within the age brackets considered suitable for military service, the mobilization is further complicated by a dearth of technical and scientific manpower to satisfy the needs of the military forces and of other essential activities. Because of the low birth rate during the depression years of the 1930's, we are faced with a decreasing number of young men reaching age 18 each year. This decrease will continue through 1953 and the trend will not be reversed until 1956.

During frontier days all citizens accepted the necessity of bearing arms to defend their homes. Generally the periods of defensive action were of relatively short duration and the action was local in character. The call to arms caused little interruption of the essential production needs of the community.

Today the situation is different. It cannot be met with the response or philosophy of frontier days. Our essential needs are more complicated and diverse, largely because of the change from an agricultural to an industrial economy and of the higher standard of living which is the product of industrial development. Requirements for defense are likewise far more complicated and diverse. The scene of action is no longer local. The weapons and equipment of the modern fighting man are complex. The development and production of better weapons and equipment requires a higher and higher level of engineering and scientific skills, especially in research and development activities.

We are now far more dependent individually upon the productive efforts of others than were our forebears. We must provide manpower to support the civil economy as well as the military effort. Interruption, or serious reduction, of industrial activities because of a policy which would remove an essential group therefrom to render extended service in uniform, may have grave consequences. It could easily seriously reduce the development and production of the very equipment needed most by our military forces.

Security of this country is not a question of uniformed manpower alone. It

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is equally a question of ability to produce goods and equipment, not only for the military forces, but also for that part of the civilian economy which is essential to our continued existence. Our potential enemies greatly outnumber us on a man-for-man basis. Study shows that wars are not won by sheer superiority in the numbers of fighting men, or by prewar military training or service alone. They are won through superior equipment and productive capacity.

Germany and Japan provide excellent examples of the effectiveness of superior equipment over preponderance of manpower. In the beginning of World War II and during the invasion of China, both countries were successful, mainly because of the quality and quantity of their equipment advantage. True, they had a certain manpower advantage too, but when the weight of Allied equipment exceeded that of Germany and Japan, the fortunes of war turned against the latter. From the beginning of time, examples may be found to illustrate that superior equipment wins over mere manpower superiority—David's slingshot, the English long bow at Agincourt, and Napoleon's artillery, to name but three.

Not only must we develop and produce superior weapons, but we must maintain the sound economy essential to continued productive capacity if the man at the front is to be effective. These requirements are part of an inseparable whole in maintaining the security of our nation.

With the balance of manpower supply in favor of our potential enemies, it is of the utmost importance that we make the most effective use of what we have. This utilization is not merely a problem of furnishing men in uniform for military service. It also involves a coordinated plan for strengthening productive agencies—designing and developing equipment to continually improve our standards of living and ability to produce; designing and developing better equipment for defense.

Any successful program of defense must take into account that the survival of the United States as a free nation will depend *on superior scientific and engineering skills* to offset the superiority in numbers of men which free nations lack. In addition to an over-all deficit in numbers for our military forces, we are faced with a critical shortage of persons having specialized skills and experience, especially in the fields of engineering and science. A basic consideration is the necessity for training and developing the specialists we need in the future—engineers, scientists, diplomats, doctors, farmers, professional military personnel. We must not repeat the mistakes we made in World Wars I and II when training for civil pursuits was, to a major extent, suspended to meet the emergency of the period. We must realize that we now face a situation of indefinite continuance, not a brief or transient one.

Should there be all-out war, the requirements of the Armed Forces will be great. It may be assumed that every physically fit young man is destined to serve in uniform, *unless it can be shown by clear and convincing evidence that he can serve the nation to better advantage in industry, agriculture, or some other pursuit which vitally affects the national health, safety, and interest.*

The policy which we advocate would involve withholding from the total pool of men of military age, presently numbering 10,000,000 physically fit between the ages of 18 and 30, only those of the highest technical and professional qualifications, and reasonable numbers of trainees to attain such qualifications. The screening procedure will involve selection of the very highest order and must be conducted with great care if public confidence is to be maintained. This policy would require the deferment of about 500,000 young men, or 5 per cent of the age group in question. This 500,000 constitutes a segment critical to present and future technical superiority. Otherwise, the requirements for technical manpower must be met out of the pool of older men, women, 4F's, and underage persons, and the flow

of younger men into technical fields will be interrupted. The young engineer is in many cases equally in demand, sometimes even more than his more experienced confrere, for much of the technology now critically important is so new that only recent students have any training whatever in its application. A belief that the technical requirements of industry can be met by men generally over military age—even if there were enough of them—is therefore a fallacy.

National Manpower Mobilization Policy

A National Manpower Mobilization Policy was promulgated by the President on Jan. 17, 1951. This statement enunciated the principle: *"each individual will be expected to serve in the capacity in which he can contribute most to the total mobilization program."* It provided for fulfilling manpower requirements not only for military purposes but also for the maintenance of a strong domestic economy, and the provision of materials for essential needs, both military and civilian. It is a basically sound policy.

However, it is evident that this policy has not been fully followed by the various executive branches of the Federal Government as the underlying basis for their procedures. In the call-up of reserves, and in the disposition of individuals after call-up, the military departments seem to give first consideration to numbers and to availability rather than to qualifications. Inadequate weight is given to the role of the individual in the essential civilian economy in determining whether or not a man should be called for military service. ROTC graduates are subject to call in substantial disregard of their individual qualifications or of their contributions in nonmilitary capacities. In the Services, the individual's military duties are primary and the utilization of his specialized skills is secondary. This permits highly inefficient use of uniformed personnel having special skills, even in those technical branches of the Service which are, at the same time, determinedly recruiting civilian engineers and scientists.

The Engineering Manpower Commission of Engineers Joint Council strongly recommends that every effort be made by all agencies of industry and government to follow implicitly the principles delineated in the National Manpower Mobilization Policy. It recommends further that in the development of a program for manpower utilization in relation to national security, more consideration be given to the value of building the potential for production of essential equipment for the Armed Forces. This is of far more importance in providing for the successful defense of the nation than is the mere build-up of numbers of military personnel. In general, it is much simpler to procure and train men for military service than it is to train men for the expansion of industrial capacity.

Definitions

In order to clarify the following discussion, it is well to outline the meaning or significance placed upon terms used to designate the various patterns proposed for manpower utilization.

(1) ***UMT, Universal Military Training*** —a term applied to any of several plans for *training* our physically fit manpower. The plan submitted to Congress by the National Security Training Commission called for the induction of young men at age 18 for six months' training. At the end of their period of training they would be placed in a reserve component for an obligated service in the reserves of 7½ years. The predominant feature of UMT plans is a peroid of *military training followed by an obligated period in a reserve component.*

(2) ***UMS, Universal Military Service*** —a term applied to any of several plans provided for an obligated period of *active military service.* The basic plan for UMS proposed that *all* physically fit men be placed in active service for two years commencing at age 18. Variations of this plan have been suggested to permit the period of service to be postponed for educational purposes, but only until graduation or cessation of training. The pre-

dominant feature of UMS plans is a period of *compulsory service in uniform for all physically fit men without regard to the occupation, capabilities, or training of the individual, or the probability that he might best serve the nation elsewhere.*

(3) *Selective Service*—a term applied to the plan established by law for *selecting* from those who have military service liability: (1) those who are to enter military service in accordance with the needs of the Armed Forces, and (2) those with special skills who are to continue to serve in the essential economy including defense industry. The predominant feature of Selective Service is the *selection of manpower for service in accordance with both need and skill.*

Universal Military Training

Most informed persons agree that for many years to come, the United States and its allies must maintain a substantial degree of preparedness. Some venture the opinion that preparedness must continue at approximately the present level for a period of twenty years; other believe as long as fifty years. If we continue to maintain 3,700,000 men in uniform, on the basis of present population distribution, about three years' service will be required of each physically fit young man either before or after his college or other training.

In an emergency of such long duration it seems advisable to establish by law the obligation of all persons to train for the defense of the nation and to defend it in time of emergency. The training phase should be universal and should exclude only those who are physically unable to take any training, military or otherwise. It should be so timed as to interfere to a minimum degree with the education or employment of the young men concerned.

After training, the trainee will normally pass into a reserve from which he will be subject to call in event of emergency. Governing such recall, there must be a system of selection which will either call the man for military service or defer him in the national interest if his retention in civilian life is essential to the national health, safety, and interest.

In considering the necessity for training, we must not lose sight of the fact that until recently, we have been relying largely upon those who comprised the Armed Forces in World War II. This is demonstrated by our Korean experience when it has been necessary to recall combat veterans of World War II for the build-up of the Armed Forces. The veteran segment of the reserve is diminishing every day, because the men and women are getting older, are acquiring physical disabilities or a dependency status; or other situations tend to make them less available for military service. While men cannot be trained in substantial numbers while the entire pool is drained for immediate service, as at present, we should move at the earliest possible moment in the direction of training our young men and creating a continuing reserve, if the nation is to be secure.

The Engineering Manpower Commission of Engineers Joint Council recommends that a practical plan for Universal Military Training be developed and enacted into law. Provision should be included to implement the reduction of our standing Armed Forces so that the training of our young men and the creation of a continuing reserve through UMT can commence as early as practicable.

Universal Military Service

Many plans have been proposed involving some form of Universal Military Service, i.e., service in uniform for *all* in a stipulated age bracket, except for those not physically fit. Modifications have been proposed to permit the period of service to be postponed for students satisfactorily pursuing courses of higher education. Other modifications suggest deferment of apprentices, or the assignment of men for compulsory service as civilians in military research and development. Generally the proposals stress a universal obligation to serve *in uniform* as being "democratic," and as such, essential to the American way of life. Actually, service

at the highest capability, whether in uniform or out of uniform, would seem to be the most desirable goal.

Should Universal Military Service be adopted, there would be a suspension in the output of engineering and scientific graduates, other than the physically unfit, needed to serve in industry, of new agricultural manpower needed for our economy, and of new teachers and educators also sorely needed. This suspension would last for two or more years under presently proposed plans. In view of the current shortages in specialized fields, we cannot afford suspension for such a period. It furthermore seems likely that the interrupted training represented by military service of such length will make the integration of these young men into industry more difficult and thus, in effect, add to the period of loss of their services.

The Engineering Manpower Commission of Engineers Joint Council, as has been stated, is in favor of a *selective* system which will co-ordinate the manpower needs of the military with the manpower requirements of essential industry, including the production of more and better equipment for defense. For this reason we are opposed to Universal Military Service as being prejudicial to national security.

Selective Service

The Selective Service System as presently constituted has been operating not only to select people for induction into military service but also to select those for retention in the essential civilian economy.

In the fields of medicine and agriculture, the various local boards and state directors of the Selective Service System have state and county boards and committees to advise them with regard to personnel selection in these fields. In the case of medicine, requests for doctors, dentists, veterinarians, and allied skills are actually submitted to the County Medical Boards for filling rather than to the Selective Service System. The County Medical Boards are in a position to designate those doctors who can best be spared to fulfill the requirements of the military services.

In the case of agriculture, state and county Agricultural Mobilization Committees have been organized under the administration of the Department of Agriculture. These committees provide facts to assist the local boards and the state directors in the Selective Service System with respect to classification of registrants in this field.

No provision exists to cover such advisory service at local and state levels, either to the Department of Defense or to the Selective Service System, in other specialized fields such as engineering, the sciences, and education. As a consequence, many local boards do not have sufficient facts to make a wise and just selection in the over-all interests of national security. The Engineering Manpower Commission of Engineers Joint Council recommends that the Selective Service System be strengthened to provide advisory services to the local and state boards for such specialized personnel through state and county advisory committees, composed of representatives of industry and the specialized professions. These committees will provide advice with respect to such personnel comparable to that now furnished in the fields of medicine and agriculture.

Armed Forces Reserve

On July 9, 1952, the Armed Forces Reserve Act of 1952 (P.L. 476) became law. In addition to providing some uniformity in the over-all administration of the reserve components, this act establishes a Ready Reserve, a Standby Reserve, and a Retired Reserve. The Ready Reserve is that portion liable to immediate recall. It is limited by the Act to 1,500,000 men, including the National Guard. The Standby Reserve includes all other reservists liable to recall but not necessarily immediately. The Retired Reserve, as its name implies, contains those reservists who are retired but may be recalled for limited duty in the event of war.

The Ready Reserve will actually contain that segment of trained reservists and units needed for an immediate mobilization effort in the event of national emergency declared by the President, or police action such as that in which we are now engaged in Korea. Outside of the National Guard and Air National Guard, it is most probable that the Ready Reservists will be called as individuals to bring the cadre of existing service units to full mobilization strength.

The Standby Reserve will contain all other reservists except those on the retired list. Within the Standby Reserve, however, there will be the active organized units which will be required in the event of total mobilization or war as declared by the Congress. The Standby Reserve thus will be similar to the Reserve as maintained before the passage of P.L. 476.

Notwithstanding testimony before the Senate Armed Services Committee by the Engineering Manpower Commission of Engineers Joint Council and others urging provisions for the *selective* recall of reservists (which testimony, we thought, was well received) the Armed Forces Reserve Act of 1952 was passed without such a safeguard. Therefore we feel that it does not provide for the best utilization of manpower in the national health, safety, and interest.

Section 4(*d*) of the Universal Military Training and Service Act (P.L. 51) provides for a total period of liability of eight years of active training and service in the Armed Forces and in a reserve component for all persons below age 26 who are inducted, enlisted, or appointed after June 19, 1951. It established, for the first time in our history, a compulsory reserve. It is evident that eventually practically all of the able-bodied young men below age 26, or older, except for those making a professional career in military service, will be in a reserve component of the Armed Forces to complete their term of liability, and thus subject to recall.

By the time they are recalled to active military service, many members of both the Ready and Standby Reserves will have acquired specialized skills and experience that would make their recall detrimental to the total defense effort. These are the persons who should be identified by a careful classification and selection process in order that the needs of defense industry and the essential civilian economy will not be seriously hampered by their recall to active duty.

Some provision must be included in the law, therefore, to conserve reservists having specialized skills and experience when their service in a civilian capacity would contribute more to the national strength and security than their service in uniform. Reservists who do not have an obligated period of service should be discharged. Reservists who have an obligated period of service should be transferred to an inactive status list from which they would not be called or from which their recall could be governed by a civilian agency or board outside the military departments. This civilian governing board should have the authority to render final decisions. It should be composed of representatives of the Department of Defense, various other governmental departments, the professional groups involved, and the military departments.

The civilian governing board would be the top board at the national level. In order to maintain public confidence and to reduce the volume of individual cases which would otherwise have to be reviewed at the national level, local and/or state boards should also be organized. The local and state boards should be composed of representatives of the professional groups involved and of the military departments. They should, however, remain civilian in character and have authority to render decisions within the framework of criteria established by the national board.

In order to reduce to a minimum the problems which would be encountered in a full-scale mobilization, there must be a continuing appraisal of the classifications of reservists to insure to the maximum possible extent that those who have

specialized skills and experience are properly classified before mobilization takes place.

Some provision must also be included to insure the continuance of the education and training of specialists needed in the future. Students who are pursuing professional and scientific courses in the colleges should be permitted to complete their study before being considered for recall to active duty. Many of them will be needed by the technical branches of the Armed Forces as well as in other essential activities of the national economy.

The Engineering Manpower Commission of Engineers Joint Council, therefore, recommends that the Armed Forces Reserve Act (P.L. 476) be amended accordingly.

ROTC

Because of impending military service there has been a greatly increased enrollment in ROTC units by students entering the colleges. In a large measure this may be attributed to the assurance of completing their college education without disturbance and of receipt of commissions on graduation.

In the past when students enrolled in the Air or Army ROTC, they had the privilege of applying for two years of advanced training *after completing two years of basic training.* Students who were enrolled in the Naval ROTC, however, were obliged to complete four years of training. Enrollment in advanced Air or Army ROTC courses therefore, until this year, has been optional on the part of the student.

With the current operation of Selective Service there has been increasing pressure exerted by the ROTC officers to have all students in the ROTC sign draft deferment agreements. These draft deferment agreements commit the student to the completion of four years in ROTC and acceptance of a commission, two years' active service upon graduation, and six years' additional service in a reserve component.

A recent survey made in the engineering colleges revealed that 16 per cent of the seniors of the class of 1952 were commissioned as a result of ROTC training as compared with 11 per cent of the previous year's graduates. Examination of the enrollments in ROTC in the *undergraduate* classes, however, shows that 23 per cent of the juniors are so enrolled, 45 per cent of the sophomores, and 55 per cent of the freshmen.

The survey from which these figures were obtained was made by the Engineering Manpower Commission in May, 1952. It covered returns from 174 out of a total of 192 engineering colleges in the United States. It is evident from this that an increasing number of engineering graduates each year will be committed to a period of service sufficiently long to hamper the needs of essential industry unless provision is made for their selective withdrawal from service liability.

To add to the problem, it has been decided, beginning this year, to convert Army and Air ROTC units to Branch General training and to discontinue curricula in the technical specialties. Upon graduation, assignments will be made to the various branches, technical and combat, in accordance with the requirements of those branches, and the training and standing of the students. The advocates of this change state as a primary advantage that it trains cadets essentially for combat and makes it possible for the Army and Air Force to obtain a larger percentage of combat officers.

The Engineering Manpower Commission heartily supports the general ROTC concept that American colleges and universities should be utilized for the purpose of training reserve officers, especially those needed in the technical branches of the service. We feel, however, that proper utilization of graduates having special training such as in engineering and science, may indicate that officers for the technical branches of the service should be obtained through the ROTC, and combat officers through Officers Candidate Schools. We therefore recommend that further study be given to the ROTC

program, especially with respect to the effects on manpower utilization of the trend toward Branch General training.

We recommend also that new criteria be established in choosing students for ROTC programs in order to assure a more equitable distribution between civilian and military needs. The present method channels into ROTC units a disproportionate share of students capable of and needed for graduate training and for other essential activities. Realistic quotas should be established in the various military categories, and every effort should be made to restrict the entrants to accord with such quotas and to match their fields of specialization.

Reservists who are ROTC graduates should be subject to the same screening, classification, and selective recall as has previously been recommended for reservists in general in the proposed amendments to the Armed Forces Reserve Act.

We also recommend that Selective Service regulations be modified to permit students in engineering, science, and other critical fields to receive the same assurance of completing their education as is now provided to those enrolled in the ROTC units.

Utilization of Persons Having Specialized and Critical Skills

Concurrently with the universal obligation of each man and woman to furnish his best service in maintaining the national security is an obligation on all agencies—military and nonmilitary alike—to utilize manpower in such manner that the most proficient service can be furnished. This is especially true with respect to those persons possessing critical and specialized skills in short supply.

The present shortage of engineers and scientists is serious because of its effect on the national economy and on national security. If we do not utilize our limited manpower effectively, we will lose technological superiority over our probable enemies. With such loss, the probability of a full-scale war with the forces of communism will become infinitely greater.

The Engineering Manpower Commission of Engineers Joint Council urges in the national interest that the following steps be taken:

(1) *Military Utilization*

(*a*) Establish manpower budgets for engineers and scientists in each activity, in accordance with actual needs for their professional skills and experience. A catalog of requirements is vital as the first step toward maximum utilization of the total supply.

(*b*) Eliminate confusion in the distinction between a *professional engineer* and *a technician* by discontinuing references in billet designations, military occupational specialties, and elsewhere, to the word *engineer* except where the position requires an engineering graduate or scientist. Re-examine those enlisted billets which now apparently require an engineering graduate or scientist to determine whether the billet cannot be filled by a competent technician. Technicians can be trained in a matter of months; the professional engineer or scientist is the product of at least four years of full time study coupled with more years of development and experience.

(*c*) Recall engineers and scientists to active duty only to the extent they can be *fully* used in their specialties.

(*d*) Provide for commissioning in their specialties all engineering graduates and scientists who are inducted through Selective Service, or who are enlisted reservists, to permit full utilization of their skills.

(*e*) Provide for interservice transfers of persons having special skills in order to provide a wide base of utilization of their skills. For example, this would permit the transfer of aeronautical engineers or meteorologists, when needed, from the Army to the Air Force or to the Navy.

(*f*) Provide for the release from active duty of those engineers and scientists not needed as such.

(2) *Civilian Utilization* (including utilization in government, agriculture, trans-

portation, manufacture, and all other activities outside of the military).

(*a*) Establish manpower budgets similar to those recommended for the military.

(*b*) Study the duties, and the proportionate time spent on each duty, of engineers and scientists, in order to transfer to supporting personnel those duties not requiring full engineering or scientific skills. Many such duties can be performed equally well, if not better, by technicians, clerks, draftsmen, and others. Do not hire engineers or scientists for positions in which their skills are not required.

(*c*) Move engineers and scientists from positions not requiring professional engineering or scientific training.

(*d*) Move engineers and scientists to positions of maximum responsibility as rapidly as possible in accordance with need, ability, and experience.

(*e*) Do not hold engineers or scientists in "intern" or training positions longer than necessary to qualify them.

(*f*) Maintain salary differentials between senior engineers and scientists and those newly graduated. Competition for new graduates has resulted in unprecedented levels of starting salaries.

Summary of Recommendations

In the interest of national security the Engineering Manpower Commission of Engineers Joint Council recommends that:

(1) All segments of our economy, governmental and non-governmental alike, follow implictly the principles delineated in the National Manpower Mobilization Policy promulgated by the President on Jan. 17, 1951, in their procedures and programs for manpower mobilization and utilization.

(2) In the development of programs and plans for national security more consideration be given to the value of building the productive potential and a coordination be effected between this and our manpower needs. Greater productive facilities are of far more importance in providing for the successful defense of the nation than is the build-up of military forces during times of peace or partial mobilization.

(3) A practical plan for Universal Military Training be developed and enacted into law. Provisions should be included to reduce our standing Armed Forces as early as practicable so that the training of our young men and the creation of a continuing reserve through UMT can be commenced.

(4) Plans for Universal Military Service as presently proposed be abandoned as unsound and prejudicial to the national security.

(5) The Selective Service System be strengthened to provide advisory service to local and state boards with respect to professional and specialized persons. Such advisory services should be provided by county and state boards, composed of representatives of industry and the professions, to furnish competent advice with respect to the essentiality in the national security of certain civilian services, and the specific value of the individual who is subject to induction based upon his specialized and critical skills.

(6) Selective Service regulations be modified so that college students in engineering, science, and other critical fields may be given the assurance of being able to complete their education before being inducted, in the same manner as is now done for those enrolled in ROTC programs.

(7) The Armed Forces Reserve Act of 1952 be amended to provide for the creation of a Civilian Reserve Governing Board, outside of the military departments, to establish criteria for, and render final decisions with respect to, the classification and mobilization assignment of reservists having specialized skills and experience, and to maintain a continuing process of classification of such reservists.

(8) The Armed Forces Reserve Act of 1952 be amended to provide for the creation of local and state Civilian Reserve Boards operating under the Civilian Reserve Governing Board to render decisions at the local level with respect to the

classification, mobilization assignment, and delay in recall to active duty of reservists, within the framework of the criteria established by the Civilian Reserve Governing Board.

(9) The Armed Forces Reserve Act of 1952 be amended to provide for the continued training of professional and scientific personnel without interruption.

(10) The present trend in ROTC units toward providing only Branch General training and discontinuing technical curricula be re-examined in the light of its effect on utilization of those with special and critical skills.

(11) New criteria be established for choosing students for ROTC programs to insure distribution of graduates between military and civilian agencies on a basis which will better satisfy national needs.

(12) Realistic quotas be established for the various ROTC programs and entrants be restricted within these quotas and in accordance with needs for their fields of specialized training.

(13) All segments of our economy, governmental and non-governmental alike, take specific steps toward full utilization of persons possessing critical and specialized skills in short supply in the best interest of the country as a whole rather than in their special interest. To this end, it is important that budgets of specialized manpower needs be established, and that the duties performed by specialized persons be thoroughly studied in order to reallocate them to less highly skilled persons to the maximum possible extent.

Conclusion

During the period of approximately two years of its existence the Engineering Manpower Commission of Engineers Joint Council, either on its own or in cooperation with other agencies, has undertaken the following activities:

(1) Offering assistance to governmental bodies and groups responsible for making and administering policy relating to the conservation and utilization of engineers and scientists.

(2) Providing help and guidance to both industry and government on other problems relating to the conservation and utilization of engineering and scientific skills.

(3) Disseminating information on the nature of engineering and the role it plays in our economy.

(4) Striving to prevent future shortages in engineering graduates by cooperating with the Engineers' Council for Professional Development and others in encouraging qualified highschool graduates to consider the opportunities in engineering and science.

(5) Advising governmental agencies and the colleges on problems relating to the deferment of engineering students from military service.

(6) Advising employers of the conditions under which deferment of engineers and scientists may be secured and of the procedure to be followed in such cases.

In furtherance of this program, we wish now to pledge our support of all efforts to assure in industry, government, and other segments of our economy, the same zeal and intelligence in selection, training, and utilization of technical manpower that we are here urging upon the military establishments; for in such measures, in our opinion, lies the opportunity for maximum contribution of the technical professions to national security.

The Engineer Becomes a Professional Manager*

By HARRY RUBEY

Professor and Chairman, Department of Civil Engineering, University of Missouri

Introduction

This Centennial is a well deserved tribute to the achievements of the engineer and to his application of science to the material welfare of mankind. The general public is beginning to realize that the engineer's universally accepted technology is the real basis for modern industry, high living standards, and national security—not the controversial political and economic nostrums which are dinned into our ears.

However, too little has been said or is generally known of the equally great contribution which the engineer has made to modern management. Beginning with Taylor, Gantt, Emerson, and their associates who originated and developed scientific management and mass production at the turn of the Century, engineers have extended their attainments and mastery to all phases of management, often at the highest levels.

Today over a third of the management of large industry in America is in the hands of engineers, over a third of mature engineering graduates now find their duties largely managerial in nature, and most engineers have important contacts with management. Management has recently become a profession into which the engineer now has preferred entree.

May I briefly summarize and document some of the evidence on this development which is unknown to the general public and too little known to engineers and engineering educators themselves. Even so comprehensive a program as that of this Centennial gives little attention to the engineer's outstanding contribution to management.

Recent Studies of Engineers in Management

Professor W. L. Warner, well recognized sociologist of the University of Chicago says in his recent book, "Social Class in America," "More and more top jobs in industry are being filled by men coming up from technical engineering schools and universities. The route up then is no longer through a hierarchy of increasing skill as it was two generations ago. The prudent mobile man today must prepare himself by education. . . . In this age of technical wizardry and large scale industry, the most prudent man will master a field like engineering or business administration to gain a maximum chance at promotion to the inner circles of management and planning."

Engineers' Joint Council Report. The most comprehensive statistics available on the engineering profession are given in a report entitled "The Engineering Profession in Transition," 1947. It shows 34 per cent of those questioned (38,000 members of six prineipal national engineering societies) doing work which is primarily administrative in nature. In another report the Council states ". . . management is clearly becoming professional in function. Engineers, as the most numerous and influential professional group in industry, are exceptionally placed to capitalize on this opportunity."

Vice-President Walter Evans of Westinghouse Electric Company has said:

"With mass production the engineer came into his own. As industry became

* Prepared for the Centennial of Engineering, Chicago, September 4, 1952.

more complex, the engineer who understood what was happening joined the lawyers and bankers in administrative positions, because industry had new problems which only the engineer could solve.

". . . during the last decade engineers have begun crowding the bankers and lawyers in this contest for high-level administrative posts. . . .

"A dramatic example of how successful the engineer has been is found in a survey conducted by Earle B. Norris, dean of the School of Engineering at the Virginia Polytechnic Institute, which showed that one-third of the largest corporations in America—50 out of 150—are headed by graduate engineers. . . .

"In looking at the results of this survey it becomes even more significant when we realize that there are 1,600 liberal arts and teachers' colleges compared to 160 engineering colleges.

"Among the engineers already distinguishing themselves in such posts are: Cleo F. Craig, president of the American Telephone and Telegraph Company; Benjamin F. Fairless, president and chairman of the board of United States Steel Corporation; Eugene G. Grace, chairman of the board of Bethlehem Steel; Charles Erwin Wilson, president of General Motors; and Crawford H. Greenewalt, president of E. I. du Pont."

Rensselaer Polytechnic Institute questioned 561 executives of large industries in 1949 with the following findings:

1. Ninety per cent see a growing demand in business and industry for executives and managers who have a background in engineering.

2. Approximately thirty-nine per cent of the executive and managerial positions in the industries represented by respondents to the survey are now held by graduates of colleges of engineering.

Time Magazine Research Report No. 1069, May 1950, summarized the answers to the questionnaire sent one-sixth of those listed in "Who's Who in Engineering." Seven per cent are corporate presidents, and an additional sixteen per cent are in other top executive positions. Thirty-five per cent are managers, chief engineers, and department heads while forty-two per cent are specialists and consultants.

Sixty-three per cent of these engineers checked administration, finance, and management as areas in which they have occupational responsibilities.

Because many management engineers are not listed in Who's Who in Engineering nor are they members of their national professional societies, the percentages of engineers engaged in management as reported by Time and by Engineers' Joint Council are doubtless low.

The American Society for Engineering Education, in a 1951 pamphlet, states, "A careful study of the number of engineering graduates who hold executive positions in industry has shown that engineers have from 10 to 20 times the probability of attaining executive positions as compared with all other college graduates."

General Motors, in a broadcast over ABC on November 26, 1951, stated in part:

"Tonight, I just want to conclude this assembly of three broadcasts in this investigation by pointing out the amazingly widespread climb of engineering-qualified students to the top, as general executives, in American enterprises—in short, the enormous individual possibilities in this opportunity, based on the record.

"According to a Columbia University survey, and I quote, I find that 'forty per cent of industrial management is engineer-trained, replacing both the lawyer and the banker in top industrial posts.'

"Look at some of the top management in our country, men with great general responsibilities. I think you would be amazed to realize how many got their training as engineers—thus trained to think precisely, trained in human values, trained to apply constructive imagination and decision.

"Largely at random, and among diversified and notable American enterprises, I've been asking questions: 'How

many of your top executives trained themselves as engineers?' This is what I found:

"I spoke last week of Bethlehem Steel, and the head of that company, who is an engineer, graduated from Lehigh.

"The president of United States Steel, having some 308,000 employees all over the world, started as an engineer, a civil engineer, graduated from Ohio Northern University. There are 13 Presidents of the United States Steel Company's subsidiary companies who started as engineers.

"There are 20 Presidents of associated companies in the great Bell Telephone System. Of these I find 10 graduated as engineers. In the parent A•T & T, over half the men who are Vice-Presidents started as engineers and advanced to the broadest duties in the business.

"Fourteen members on the Board of Directors of the Standard Oil Company of New Jersey are engineers. The Chairman of the Board in this great worldwide enterprise is an engineer, graduated from Syracuse University.

"At least 15 top executives of Anaconda Copper and its major subsidiaries are graduate engineers. Over half the Vice-Presidents and 90% of the top executives in the five divisions of Union Carbide started up the ladder as engineers.

"Nearly half the top officials of the General Electric Company started as engineers. In fact, the Chairman of the Board was first graduated as an engineer at the University of Wisconsin and studied law as well. And, as you may know, Mr. C. E. Wilson, lately the nation's mobilization chief, while not a graduate engineer, was technically trained at the Mechanics' Institute in New York and, among other duties, he advanced through G. E.'s Engineering Department.

"The Chairman of the Board of RCA completed special engineering night courses at Pratt Institute and 8 of the Vice-Presidents got their executive training as engineers.

"The Chairman of the Board of Directors of General Motors is an engineer, graduated from M. I. T. The President of General Motors is an engineer, graduated from Carnegie Institute. One of the four Executive Vice-Presidents is an engineer, graduated from the University of Illinois. Sixteen of the Corporation's Vice-Presidents are engineers. As a matter of fact, there are sixteen members of the Board of Directors of General Motors who are engineers.

"Now, there's time to cite only some of these findings, but such sample cases as I found simply support the over-all findings of the Columbia University survey, namely—and may I repeat—that 'forty per cent of industrial management today is engineer-trained, replacing both the lawyer and the banker in top industrial posts.' I think there's news in that."

President Gurley of the Sante Fe Lines said at the A.R.E.A. meeting last March, "No longer can engineers confine their activities to design, construction, and maintenance. Theirs must be a broader outlook. Both management and the engineers themselves have mistaken concepts of where the engineer fits into the picture. Engineers should concern themselves more with administration. Their logical technological reasoning can help improve the economical operation of the railroads, reduce the damage to property being shipped, and develop more revenue-paying business now going to competitive forms of transportation." It will be noted that President Gurley indicates new activities beyond those traditional to railroad engineering.

Herbert Hoover even more recently has written, in connection with this Centennial, "In the gigantic field of applied science, the trained engineer is now emerging into the executive field. It is said that the heads of more than one-half of the great productive corporations are trained engineers."

Conclusion

So while at this Centennial we honor the engineer for his technology, we should

honor him equally for his contribution to management.

The data presented earlier in this paper prove that an engineering education is a good preparation for positions in top management, but it does not follow that the same large proportion of engineering students of today will be among the top executives of the next generation. When the older top executives were starting their careers, they had little competition from the graduates of schools of business administration. That is not the case today. In fact, many of the larger manufacturing companies will freely admit that they find business administration graduates more interested in, and more easily trained for, general management positions than are engineering graduates.

The conditions I have just described are so bad that according to the National Society of Professional Engineers, two-thirds of industrial concerns make no effort to tell their engineers of management openings. Fortunately, young engineering graduates who realize the importance to themselves of a knowledge of management principles, and who show their employers that they are interested, have at least as good an opportunity to enter the management side of industry as did the engineers of the earlier generation.

Only a few engineering students can afford the time required for the detailed and specialized courses in industrial engineering curricula, but all engineering students can afford the small amount of time needed to introduce them to the fundamentals of management. This also will show them that they should continue to study these fundamentals during their early years after graduation when management problems will surround them, although in most cases they will not be asked to assist in their solution.

While many engineers will not function as managers, yet the higher types of professional engineers must understand and cooperate with management.

A promising movement for our country lies in that new profession of management, largely practiced by engineers, which is motivated by a drive to make man's work effective rather than by the older drives for financial or political power. With professional management and technology, America's future is assured. Other national policies and procedures then will trend naturally into desirable patterns.

Unless engineers and engineering educators seize and answer this call to leadership, others will grasp and exploit it. Then the engineering profession, engineering education, and industry will have missed a great opportunity. As a final thought, if more engineering graduates become managers, then more support for engineering education will be forthcoming.

5th College-Industry Conference

THEME . . . Opportunities in Engineering

Sponsored by the Relations with Industry Division of ASEE and Northwestern University at Northwestern Technological Institute, Saturday, January 31, 1953.

Minutes of Executive Board Meeting

A meeting of the Executive Board of the American Society for Engineering Education was held on Thursday, November 13, 1952, at the Statler Hotel, Washington, D. C. Those present were: W. R. Woolrich, *President*; M. M. Boring, J. H. Lampe, E. A. Walker, W. C. White, *Vice Presidents*; C. L. Skelley, *Treasurer*; A. B. Bronwell, *Secretary;* M. C. Merrill, *Office Secretary.*

The Secretary reported on activities as follows:

a. An appropriation of $3000 has been received from The Engineering Foundation for the project of the Committee on Evaluation of Engineering Education. An application has been made for a like appropriation from the Engineers Joint Council.
b. Letters have been sent to the Presidents and Deans of Engineering Colleges summarizing the results of meetings which Society Officials have held with the Army, the Air Force, and the American Council on Education relating to the ROTC Programs.
c. Letters have been sent to the Deans of Engineering Colleges suggesting that they urge college graduates to carry on personnel interviews and make tentative job commitments before they enter the Armed Services so that they will return to acceptable engineering jobs. The purpose of this program is to achieve a better utilization of technical manpower among those who are destined for duty in the Armed Forces.
d. The December and January issues of the JOURNAL OF ENGINEERING EDUCATION will be devoted to papers presented at the Centennial of Engineering.
e. The Society's application for representation on the United States Commission on UNESCO was not approved, although favorable consideration was given. The Chairman of the Membership Committee of the U. S. Commission has suggested that the Society re-apply for admission.

Treasurer's Report

The Treasurer discussed the financial report for the first quarter of 1952. Most items of income and expense are in line with those of the preceding year except salaries, which were increased by action of the Executive Board. The quarterly report for 1952 includes the salary of the Assistant Secretary who was not on the payroll during the corresponding period of 1951.

The campaign for increased advertising, conducted by Assistant Secretary Watson, has thus far yielded $2700 in new revenue for the current year. It is anticipated that this will be still further increased before the fiscal year is concluded.

Projected Society Finances

The Secretary submitted to the Executive Board a summary of financial operations for the past five years and tentative forecast of the financial outlook in the future. The estimated income provides for increases in revenue from advertising, membership, and institutional membership. The estimated expense provides for the addition of 1½ office secretaries and probable increases in expenses including rising costs of publication. The report shows that the Society has one staff member to every 2000 members, whereas other leading engineering societies have approximately one staff member to every 200 to 400 society members. The Society dues are one-fourth to one-fifth of those of other engineering societies. The small

overhead expense and low dues structure has been made possible by: (a) free rent and facilities (Northwestern University supplies the office space and office furniture without cost to the Society); (b) prudence in travel expense; (c) avoiding subsidies to Sections; (d) and a minimization of the collateral services rendered to the membership.

Representatives of A.S.E.E. to Conference on Education in London

The Secretary read a letter from C. E. Davies, Secretary of ECPD, requesting the ASEE to appoint its President as a delegate to an International Conference on Engineering Education which will be held in London during the week of January 12th. This conference will be attended by representatives from all European countries outside the Iron Curtain. Its purpose will be to establish a European conference on engineering education and explore possibilities of instituting a European Society for Engineering Education. The Executive Board expressed the view that it is essential that the ASEE be represented, since it deals primarily with Engineering Education. The President was appointed as the official representative, with an appropriation of $1000 for travel expense.

Reports of Vice Presidents

Vice President Boring suggested, and the Executive Board approved, sending invitations to Queens University, McGill University, and Montreal University to affiliate with the New York Section of the ASEE until such time as they should desire to institute their own Section. It was also suggested that Nova Scotia College might be invited to join the New England Section, and British Columbia, the Rocky Mountain or Pacific Northwest Section. Mr. Boring will correspond with the Canadian Institutions in regard to their desires in these matters.

The suggestion has been made that the name of the Missouri Section be changed to the Missouri-Arkansas Section. Mr. Boring will correspond with officers of the Section relating to this change.

Vice President Walker, reporting for the ECRC, announced that a questionnaire for information for the new publication Review of Research will be sent to the Engineering Colleges in the near future. ECRC has made tentative plans for its program for the Annual Meeting in June.

Vice President J. H. Lampe, reporting for the ECAC, briefly summarized the ROTC meetings which were held in Washington, results of which have been summarized in letters to the Presidents and Deans of Engineering Colleges. The Executive Committee of the ECAC has prepared plans for the June Program. The International Relations Committee again will hold a dinner meeting at which educators and administrators of engineering colleges from foreign lands will be invited. The Secondary School Committee, the Selection and Guidance Committee, and the Manpower Committee will each have conference programs at the Annual Meeting.

Vice President W. C. White, reporting for Divisions and Committees, stated that the Division of Educational Methods had requested an exhibit of teaching aids at the Annual Meeting, in cooperation with the Society's Committee on Teaching Aids. The Executive Board voted to approve such an exhibit.

Vice President White also presented a request of the Mathematics Division for a subsidy of $100 to be used to obtain speakers for a conference on Computers at the Annual Meeting. It was pointed out that the Society had a practice of not paying travel expenses of speakers to the Annual Meeting. However, the suggestion was made that this conference might be arranged as a Summer School. The Society permits Summer Schools to charge a registration fee of not more than $1.50 per member per day to defray expenses in the operation of the Summer School. This would give the Mathematics Division funds for the Conference on Computers in addition to its annual budget.

Report of Manpower Committee on ROTC Quotas

The following report was presented:

The Manpower Committee of the American Society for Engineering Education is gravely concerned over the plans of the Armed Services for expanded R.O.T.C. programs and the consequent effect upon an adequate supply of trained men with high ability for the civilian functions of industry, public health, agriculture and government, essential for support of the national effort.

Under existing programs of the Services, the number of R.O.T.C. graduates receiving commissions will more than double within the next few years, to a total of over 65,000. In 1955 when the number of degrees granted to men is expected to reach its critical low point, to be followed under existing policies by a gradual rise, R.O.T.C. graduates will constitute 40% of the entire male class and nearly 60% of that in engineering.

Pending legislation, moreover, will extend to a substantial number of R.O.T.C. students in the Army and Air Force, the opportunity for a college education with free tuition and a living allowance, now offered under the regular Navy R.O.T.C. program. Such an opportunity added to assure deferment until graduation and the selective process of the R.O.T.C. itself is certain to attract students of the highest ability, many of whom could make outstanding contributions to research in physical, biological or social science, or in engineering.

These men will be committed to at least two years of military service upon graduation and to several additional years in the Reserve, from which they almost certainly would be called in the event of a major War, when the demand will be greatest for research and production. As reserve officers, their contributions to the civilian national effort would be subject to review only by the Military Services.

The Manpower Committee of the American Society for Engineering Education urges that the implications of such a program be reviewed at the highest levels of the Federal Government.

A motion to approve the report and transmit it to Members of the Engineering Manpower Commission, the proper officials in the Armed Services, and the Deans of Engineering Colleges was approved.

(Subsequent to the meeting, Mr. Donald Bridgman, chairman of the ASEE Manpower Committee, suggested that distribution be withheld pending preparation of a more comprehensive report covering the problems relating to ROTC, selective service, and other phases of the technological manpower problem for submission to the new Secretary of Defense, Charles Wilson.)

Meeting of ECAC with Officials of MSA and TCA

Dean Lampe announced that a meeting had been arranged between Officers and Executive Committee Members of ECAC and ASEE Executive Board members with some of the top officials in the Mutual Security Agency and Technical Cooperation Administration to discuss international programs relating to technological education. The Government's Technical Assistance Program includes substantial areas dealing with research and technological education and the ECAC is therefore taking steps to establish closer working relationships with the MSA and TCA in order to make it possible for these agencies to get the advice and assistance of Deans of Engineering Colleges. (The meeting was held in Washington on November 13, 1952, and resulted in the recommendation that the ECAC appoint a small advisory committee to work with similar committees of MSA and TCA.)

Annual Meeting Plans

The Secretary reported on discussions with Dean Weil and Dr. Grinter relating to the plans for the Annual Meeting. The Executive Board voted to hold a business general session on Monday afternoon, 3:00–5:00 P.M. The program of this general session would include committee reports, a report on Society activities, and other general business matters.

Associate Institutional Membership Drive

The Secretary stated that Mr. McKeon is preparing material to be sent out to companies which are prospective Associate Institutional Members. It is hoped that a

substantial number of new Associate Institutional Members can be added this year.

President Woolrich read a letter from Col. C. E. Davies, Secretary of EJC, stating that the Societies making up EJC had expressed hesitation about admitting other Societies to the Unity Organization which have company memberships. Dean White emphasized that the classification of membership in the ASEE is defined by the Constitution and that Associate Institutional Membership classification was included in order to provide a vitally necessary liaison between industries and the Engineering Colleges. Without close liaison between industries and our educational institutions, education would become sterile and academic and would lose the vitality which has been gained by close industry affiliation. It was the opinion of the Board that even closer liaison with industry is desirable and would result in strengthening engineering education and the engineering profession.

The Executive Board suggested that the Division of Relations with Industry consider the problem of studying the relationships between Engineering Colleges and industry in order to make recommendations as to more effective lines of cooperation.

President Woolrich appointed a committee consisting of Jesse McKeon, Donald Bridgman, M. M. Boring, L. Fletcher, and C. L. Skelley to explore ways of increasing membership from among industrial people, particularly the leading engineering personnel in industry. This committee would also recommend means of increasing participation of industrial members in Society activities.

Interchange of Foreign Students for Work Experience

A letter from Dr. Dees of the National Science Foundation was read. This relates to a new organization, the International Association for the Exchange of Students for Technical Experience. The Science Foundation has cooperated with this organization in attempts to develop outlets for technical experience of British students in industries in the U. S. Professor A. H. Tichenor, Jr., of Purdue University has been appointed Chairman of a group in the United States to develop this program.

Earlier in the year, Dean Steinberg was appointed as ASEE representative to the Committee which is studying these proposals. The matter had been referred to the Relations with Industry Division of the ASEE, for their comments. Both the Executive Board Members and the Division of Relations with Industry officers expressed concern over the operational difficulties of such a program. It was pointed out that because of security restrictions, most companies have regulations against hiring aliens and that this made it difficult to place foreign students in American industries. The question was also asked why the United States should bring over a whole new group of students for work experience in this country when there are already large numbers of British and foreign students in this country attending our educational institutions, many of whom will undoubtedly seek job experience before returning to their own country? The suggestion was made that British students could probably get comparable work experience in plants either in England or in Europe, where travel distances and expenses are considerably lower. The Board expressed willingness to cooperate with the project but felt that the ASEE could not take on the responsibility for it or for handling the placement of foreign students in American industries.

Future Annual Meetings

The Secretary read letters from Dean Tupper of the University of Toronto and Dean Eckel of the University of Colorado inviting the ASEE to hold future Annual Meetings at their respective institutions. This was deferred for future action.

Research Study of Educational Methods Division

The Educational Methods Division has proposed to conduct a research study with

the objective of establishing correlations between success of engineering graduates and various factors in the educational program. The Educational Testing Service is planning a somewhat different study to determine primary factors which contribute to success and has solicited funds from industry to conduct this study. The Educational Methods Division of the ASEE is proposing to cooperate with the Educational Testing Service in developing a common project.

The primary concern of the Executive Board relates to the solicitation of funds. The Board suggested that inasmuch as the Educational Testing Service had initiated the solicitation of funds and would probably provide the personnel and facilities to conduct the study, the most expeditious way seemed to be to allow ETS to continue the solicitation, with the Education Methods Division of the ASEE serving in an advisory capacity in helping to develop the testing methods.

Institutional Membership

The Executive Board voted to accept the application of the Standard Oil Development Company for Associate Institutional membership.

The Board also voted to accept the application of Spring Garden Institute for Affiliate Institutional membership.

Respectfully submitted,
ARTHUR BRONWELL,
Secretary

ASEE Sponsored Seminar on Improvement of Teaching

The seminar on Teaching Methods in the Advanced Engineering Program which was jointly sponsored by ASEE and the General Electric Company and held in Schenectady June 16–21, 1952, had at least two unusual features: it was pointed toward teaching method rather than subject matter, and the participating teachers were assigned active roles as problem solvers instead of being passive listeners.

The importance of helping the student learn how to deal competently with engineering situations that are new to him, together with having him learn to do this by practice in doing it, has been recognized by many individuals and by ASEE committees, and has been emphasized recently in the work of the Committee on Improvement of Teaching. Also realistic problem solving as a goal and as a teaching method has been developed and successfully employed in the Advanced Engineering Program of the General Electric Company for more than twenty-five years, and, indeed, has been its distinguishing feature. (Incidentally, the program was established because most engineering graduates were found to be deficient in their ability to deal with new situations on their own initiative and in terms of fundamental principles.) Thus when the question came from the General Electric Company as to what it could do to further the cause of improvement of teaching, the suggestion was made that it might acquaint teachers with the philosophy and methods of the Advanced Engineering Program. It was not expected that these would be directly applicable to engineering classes but rather would suggest and stimulate improvements that individual teachers might work out for themselves. Thus discussions of how the philosophy and method might be adapted to college teaching were a planned part of the program.

Consistent with the principle of learning by doing, accepted by both the Committee on Improvement of Teaching and the Advanced Engineering Program, the attending teachers were given the philosophy of the program by participating in it as students. The problem solving method itself was used to demonstrate the problem solving method. The seminar members began by taking the entrance examination and went on to work and discuss three problems during the week. Brief discussions of the adaptation of the philosophy to teaching occurred every day, and the closing period of the seminar was devoted to overall generalizing and the drawing of conclusions. It was not by any means a week of leisure; the schedule called for outside work on problems during most of the evenings. However, one afternoon was devoted to a plant inspection trip, one evening to a smoker, and the week ended with a banquet.

The seminar was conducted by two regular supervisory staff members of the General Electric Advanced Engineering Program, D. R. Mack and Henry Lehmann, assisted by Professor D. W. VerPlanck of Carnegie Institute of Technology, and these men deserve the credit for the success of the seminar. The entrance examination and two of the problems were typical of the Advanced Course although somewhat scaled down in length because of the shorter time available, and the third was an Advanced Course type of problem which had been developed and used in college teaching. The problems required six to ten hours' work each, were built around

realistic engineering situations, and were of such novelty and level of difficulty as to interest and challenge most of the participating teachers. Problem material was drawn impartially from the general fields of electrical and mechanical engineering.

All the expenses of the seminar, including travel and living costs, were borne by the General Electric Company. Meetings of the seminar were held in Union College classrooms, and members were housed most comfortably in a fraternity house on the campus. Living and working together for a week were conducive to spontaneous informal discussions of education that occurred at any and all hours.

Attendance was limited to twenty-five. Deans or other administrative officials of about fifty institutions throughout the United States were each invited to nominate one candidate, and promptness of response was an important factor in the final selection, since time was short. Some homogeneity of the group was believed, and later found to be, desirable, and so it was suggested that candidates be teachers of either electrical or mechanical engineering, be between twenty-five and thirty years old, and preferably have master's degrees.

While it is difficult to measure the success of an undertaking such as this, the staff and members of the seminar were enthusiastic in their reactions to it. The results of the stimulating week will show up in improvements in future teaching by the participants. We recommend that it be carried on next year on substantially the same basis as this year.

Respectfully submitted,

K. B. McEachron, Jr.

B. R. Teare, Jr.

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny	West Virginia University	April 17–18, 1953	C. H. Cather, West Virginia University
Illinois-Indiana	Rose Polytechnic Institute	May, 16, 1953	H. A. Moench, Rose Polytechnic Institute
Kansas-Nebraska	University of Kansas	Oct. 24–25, 1952	M. A. Durland, Kansas State College
Michigan	Detroit Institute of Technology	May 9, 1953	C. C. Winn, Detroit Institute of Technology
Middle Atlantic	University of Delaware	May 2, 1953	W. B. Plank, Lafayette College
Missouri	Washington University	April 11, 1953	G. F. Branigan, University of Arkansas
National Capital Area	Catholic University of America	Oct. 7, 1952	L. K. Downing, Howard University
	Howard University	May 9, 1953	
	University of Maryland	Feb. 3, 1953	
New England	Worcester Polytechnic Institute	Oct. 18, 1952	E. T. Donovan, University of New Hampshire
North Midwest	Marquette University	Oct. 9–10, 1953	S. J. Chamberlin, Iowa State College
Ohio	University of Cincinnati	May 2, 1953	H. K. Justice, University of Cincinnati
Pacific Northwest	Washington State College	April 24–25, 1953	J. P. Spielman, Washington State College
Pacific Southwest	California State Polytechnic College	Dec. 29–30, 1952	C. E. Cherry, College of Marin
*Rocky Mountain	University of Wyoming		C. A. Hutchinson, University of Colorado
*Southeastern	Louisiana State University	March, 1953	D. V. Terrell, University of Kentucky
Southwestern	University of New Mexico	April 3 & 4, 1953	M. L. Ray, University of Houston
Upper New York	Rochester Institute of Technology	October, 1953	R. M. Campbell, Alfred University

Members of the Society are welcome at all Section Meetings

*** No Date Set.**

New Members

AGARWAL, PAUL D., Instructor in Electrical Engineering, Polytechnic Institute of Brooklyn, Brooklyn, N. Y. F. A. Wahlers, J. W. Hostetter.

AHONEN, CHARLES O., Associate Professor of Physics, Northeastern University, Boston, Mass. H. K. Brown, W. C. White.

ALDRICH, HARL P., JR., Assistant Professor of Soil Mechanics, Massachusetts Institute of Technology, Cambridge, Mass. A. J. Bone, H. R. Bartlett.

ANDERSON, EDWARD P., Assistant Professor of Electrical Engineering, Brigham Young University, Provo, Utah. G. W. Carter, R. D. Baker.

ARNESON, BLAYNE E., Instructor in Electrical Engineering, Milwaukee School of Engineering, Milwaukee, Wis. F. J. Van Zeeland, F. Kaufmann.

BACHELDER, ALFRED C., Assistant Professor of Mechanical Engineering, University of Rhode Island, Kingston, R. I. J. Parker, D. Bradbury.

BAILEY, JOHN A., Development Engineer, Thermal Power Sys. Division, General Electric Company, Schenectady, N. Y. N. P. Bailey, G. K. Palsgrove.

BALDWIN, DAVID, Instructor in English, Rensselaer Polytechnic Institute, Troy, N. Y. S. P. Olmsted, F. Abbuhl.

BARICH, STEVE S., Assistant Professor of Drawing, University of Minnesota, Minneapolis, Minn. R. F. Schuck, R. J. Moore.

BARRETT, THEODORE HARVEY, Associate Professor of Civil Engineering, Michigan College of Mining and Technology, Houghton, Mich. W. C. Polkinghorne, G. W. Swenson.

BARUS, CARL, Assistant Professor of Electrical Engineering, Swarthmore College, Swarthmore, Pa. J. D. McCrumm, H. M. Jenkins.

BATCH, JOHN M., Instructor in Mechanical Engineering, South Dakota State College, Brooklings, S. D. L. L. Amidon, E. E. Johnson.

BATEMAN, JOHN H., Professor of Civil Engineering, Louisiana State University, Baton Rouge, La. J. H. Bateman, A. B. Bronwell.

BELAVIC, ANDREW M., Instructor in Engineering Drawing, Case Institute of Technology, Cleveland, Ohio. O. M. Stone, W. E. Nudd.

BLAKEMORE, ROBERT E., Assistant Director of Student Personnel and Professor of Psychology, School of Mines, Rapid City, S. D. W. E. Wilson, E. E. Clark.

BLANCHARD, RALPH S., JR., Instructor in Mechanical Engineering, Northeastern University, Boston, Mass. A. J. Ferretti, E. E. Mills.

BLOMQUIST, GAIL C., Associate Professor of Civil Engineering, Michigan State College, East Lansing, Michigan. D. W. Ryckman, F. R. Theroux.

BRADFORD, HOWARD M., Instructor in Technical Institute, Purdue University, Lafayette, Ind. A. P. McDonald, A. W. Collins.

BURRELL, FREDERICK S., Assistant Professor of Mechanical Engineering, Swarthmore College, Swarthmore, Pa. J. D. McCrumm, W. J. Cope.

BURSIK, JOSEPH W., Instructor in Mechanical Engineering, Rensselaer Polytechnic Institute, Troy, N. Y. G. K. Palsgrove, J. G. Fairfield.

CALENDAR, H. L., Assistant Professor of General Engineering, Rutgers University, New Brunswick, N. J. S. P. Owens, M. T. Ayers.

CHAPITIS, WILLIAM J., Assistant Professor of English and Modern Languages, Colorado School of Mines, Golden, Colo. W. M. Richtmann, G. W. LeMaire.

CHUTE, GEORGE M., Professor of Electrical Engineering, University of Detroit, Detroit, Mich. R. W. Ahlquist, J. J. Uicker.

CLEARY, JOHN F., Instructor in Mechanical Engineering, Case Institute of Technology, Cleveland, Ohio. E. Laitala, G. L. Tuve.

CLIFFORD, LLOYD E., Instructor in Engineering, University of Santa Clara, Santa Clara, Calif. R. K. Pefley, H. H. Aiken.

COCHRANE, EDWARD L., Dean of Engineering, Massachusetts Institute of Technol-

ogy, Cambridge, Mass. J. R. Killian, Jr., H. L. Hazen.

COLE, LARRY, S., Professor and Head, Electrical Engineering, Utah State Agricultural College, Logan, Utah. J. E. Christiansen, M. J. Greaves.

CORLETT, ALBERT V., Head of Mining Dept., Queen's University, Kingston, Ont., Canada. A. Jackson, A. Butts, W. J. Rundle.

CREDE, CHARLES E., Chief Engineer, The Barry Corporation, 700 Pleasant Street, Watertown 72, Mass. H. K. Brown, E. E. Mills.

D'AVELLA, JOSEPH X., Instructor, Department of Industrial Management, Boston College, Chestnut Hill, Mass. W. R. Grogan, P. D. O'Donnell.

DEEMER, KENNETH C., Professor of Applied Mechanics, University of Kansas, Lawrence, Kans. F. L. Brown, R. S. Tait.

DICK, WILLIAM K., Instructor in Electrical Engineering, Washington University, St. Louis, Mo. J. W. Hammann, R. T. Webb.

DIOS, ZOLTAN B., Instructor in Electrical Engineering, University of Kansas, Lawrence, Kans. D. G. Wilson, W. P. Smith.

DOLAN, THEODORE, Instructor in General Engineering Drawing, University of Illinois, Chicago, Ill. C. J. Carlson, S. M. Futral, Jr.

DOYLE, LAWRENCE E., Associate Professor of Mechanical Engineering, University of Illinois, Urbana, Ill. K. J. Trigger, C. J. Starr.

DRUCKER, EUGENE E., Assistant Professor of Mechanical Engineering, U. S. Naval Postgraduate School, Monterey, Calif. H. M. Wright, P. J. Kiefer.

DYSON, LESLIE M., Assistant Professor of Electrical Engineering, Louisiana Polytechnic Institute, Ruston, La. B. T. Bogard, A. C. Thigpen.

EATON, MELVILLE E., Head of Engineering, University of Alabama Center, Mobile, Ala. W. McIlvaine, A. B. Bronwell.

ELBERFELD, JOHN, Dean of the College, Worcester Junior College, Worcester, Mass. W. C. White, W. T. Alexander.

ELMER, ROBERT W., Assistant Professor of English, Rensselaer Polytechnic Institute, Troy, N. Y. F. Abbuhl, S. P. Olmsted.

EVANS, JAMES P., Instructor in Basic Courses, Capitol Radio Engineering Institute, Washington, D. C. E. L. Radabaugh, A. Preisman.

FEZANDIE, EUGENE H., Professor of Mechanical Engineering, Stevens Institute of Technology, Hoboken, N. J. K. J. Moser, R. O. Vuilleumier.

FORRESTER, JAMES D., Professor of Mining Engineering, Missouri School of Mines, Rolla, Mo. C. L. Wilson, E. W. Carlton.

FRIEND, FREDERICK B., Lecturer in Applied Physics, University of Toronto, Toronto, Ont., Canada. L. S. Lauchland, K. B. Jackson.

GULLATT, SAM P., JR., Associate Professor of Electrical Engineering, Louisiana Polytechnic Institute, Ruston, La. B. T. Bogard, A. C. Thigpen.

HAGIST, WARREN M., Assistant Professor of Mechanical Engineering, University of Rhode Island, Kingston, R. I. D. Bradbury, F. Votta.

HANSEN, THOMAS L., Professor and Head, Department of Architecture and Architectural Engineering, University of Colorado, Boulder, Colo. C. L. Eckel, D. M. Carlson.

HASAN, MUBASHIR, Assistant Professor of Civil Engineering (on leave), The Punjab College of Engineering and Technology, Lahore, Pakistan. F. M. Dawson, E. B. Kurtz.

HAUER, NELSON, A., Head, Industrial Education Department, Louisiana State University, Baton Rouge, La. W. R. Woolrich, F. F. Pillet.

HEAFIELD, KENNETH, Associate Professor of English, Michigan College of M. & T., Houghton, Mich. F. L. Partlo, T. C. Sermon.

HEARNE, HOLLIS C., Associate Professor of Mathematics, Louisiana Polytechnic Institute, Ruston, La. A. C. Thigpen, B. T. Bogard.

HENDERSON, FRANK J., Chief Draftsman, Engineering, Jervis B. Webb Company, Detroit Mich. H. Gudebski, K. E. Smith.

HIXSON, WILLIAM A., Assistant Professor of Electrical Engineering, School of Mines, Rapid City, S. D. A. R. Colgan, E. B. Hunt.

HOFFMAN, SIDNEY, Assistant Professor of Mechanical Engineering, Syracuse University, Syracuse, N. Y. D. U. Greenwald, B. H. Norem.

HOLLY, NORMAN E., Assistant Director, Sinclair College, Dayton, Ohio. W. R. Woolrich, A. B. Bronwell.

HOLUB, RICHARD W., Instructor in English, Fairleigh Dickinson College, Rutherford, N. J. W. H. Foster, S. J. Tracy.

HUNTER, HAROLD O'D., Chairman, Division

of Engineering, Hillyer College, Hartford, Conn. G. Robley, W. J. Wohlenberg.

JAGGER, JAMES M., Personnel Director, Arthur D. Little, Inc., Cambridge, Mass. C. S. Keevil, L. C. Jenness.

JENSEN, IVAN R., Professor of Civil Engineering, University of North Dakota, Grand Forks, N. D. E. L. Lium, A. Koth.

JEWELL, ARTHUR D., Assistant Principal, Armstrong High School, Washington, D. C. L. J. Purnell, E. R. Welsh.

JOHNSON, ROBERT C., Assistant Professor of Chemical Engineering, Washington University, St. Louis, Mo. D. F. Chamberlain, W. P. Armstrong.

JONES, EVERETT L., Instructor in Engineering Extension, University of California, Los Angeles, Calif. J. C. Dillon, R. R. O'Neill.

KATZ, ADOLPH I., Assistant Professor of Textile Engineering, Lowell Textile Institute, Lowell, Mass. M. Hindle, M. E. Gelinas.

KEMP, C. ERNEST, Assistant Professor of Geology, Michigan College of M. & T., Sault Ste. Marie, Mich. H. L. Crawford, C. Russell.

KENERSON, WALDO I., Professor of Civil Engineering, Michigan State College, East Lansing, Mich. D. W. Ryckman, D. J. Renwick.

KIBBEY, DONALD R., Instructor in Industrial Engineering, Ohio State University, Columbus, Ohio. P. N. Lehoczky, L. D. Jones.

KISTLER, SAMUEL S., Dean, College of Engineering, University of Utah, Salt Lake City, Utah. A. L. Taylor, M. E. Van Valkenburg, O. C. Haycock.

KLINE, STEPHEN J., Assistant Professor of Mechanical Engineering, Stanford University, Stanford, Calif. J. B. Franzini, W. G. Ireson.

KRINSKY, HERMAN Y., Instructor in Chemical Engineering, Pratt Institute, Brooklyn, N. Y. R. F. Shaffer, K. E. Quier.

KROMHOUT, ROBERT A., Instructor in Physics, University of Illinois, Urbana, Ill. A. F. Silkett, W. K. LeBold.

LEMLICH, ROBERT, Assistant Professor of Chemical Engineering, University of Cincinnati, Cincinnati, Ohio. H. K. Justice, W. Licht.

LEONARDS, GERALD A., Assistant Professor of Soil Mechanics, Purdue University, Lafayette, Ind. F. W. Stubbs, Jr., M. B. Scott.

LYNN, WALTER R., Instructor in Civil Engineering, University of Miami, Miami, Fla. M. I. Mantell, J. H. Clouse.

MCBRIDE, EDWARD J., Chairman, Department of Mechanical Engineering, University of Kansas, Lawrence, Kans. L. O. Hanson, R. S. Tait.

MCCONNELL, HOWARD M., Assistant Professor of Electrical Engineering, Carnegie Institute of Technology, Pittsburgh, Pa. W. P. Caywood, G. W. Penney.

MCCUAN, MARVIN G., Professor and Chairman, Department of Engineering and Mathematics, Amarillo College, Amarillo, Tex. W. W. DeVaney, W. E. Street.

MCWILLIAMS, ROBERT L., Staff Assistant, Educational Relations, Public Relations Dept., General Motors Corp., Detroit, Mich. K. A. Meade, E. L. Yates.

MORECOCK, EARLE M., Supervisor Electrical Department, Rochester Institute of Technology, Rochester, N. Y. G. H. LeCain, L. F. Smith.

MORGAN, DAVID H., Dean of the College, Agricultural and Mechanical College of Texas, College Station, Tex. H. W. Barlow, J. P. Abbott.

MOULTROP, KENDALL, Assistant Professor of Civil Engineering, University of Rhode Island, Kingston, R. I. C. B. Clarke, H. Campbell.

MURPHY, DANIEL J., Representative, International Textbook Company, Scranton, Pa. (Home address: 87–44 62 Rd., Rego Park, N. Y.) R. E. Wilson, L. W. Tice.

MYERS, HERBERT L., Assistant Professor of Electrical Engineering and Mathematics, U. S. Naval Postgraduate School, Monterey, Calif. F. E. LaCauza, R. K. Houston.

O'DONNELL, PAUL D., Assistant Professor of Industrial Management, Boston College, Boston, Mass. P. R. Swan, W. R. Grogan.

OVERHOUSE, JOHN A., Instructor in Civil Engineering, Michigan State College, East Lansing, Mich. F. R. Therous, D. W. Ryckman.

PANLILIO, FILADELFO, Associated Professor and Head of Civil Engineering, University of the Philippines, Quezon City, P. I. J. A. Van den Broek, A. B. Bronwell.

PECK, CHARLES F., JR., Assistant Professor of Civil Engineering, Carnegie Institute of Technology, Pittsburgh, Pa. F. T. Mavis, J. W. Graham.

PIERCE, J. PHILIP, Associate Professor of Mathematics, U. S. Naval Postgraduate

School, Monterey, Calif. F. E. LaCauza, R. K. Houston.

RACE, EDWARD A., Assistant Professor of Mathematics, Norwich University, Northfield, Vt. C. A. Renfrew, M. W. Connon.

REESE, RAYMOND C., Consulting Engineer, P. O. Box 58, Toledo 1, Ohio. W. R. Woolrich, A. B. Bronwell.

SALE, CLARENCE M., Assistant Professor of Mechanical Engineering, Southern Methodist University, Dallas, Tex. E. H. Flath, C. A. Besio.

SAUNDERS, ROBERT M., Assistant Professor of Electrical Engineering, University of California, Berkeley, Calif. A. S. Levens, H. D. Eberhart.

SAXER, EDWIN L., Professor of Civil Engineering, University of Toledo, Toledo, Ohio. J. B. Brandeberry, W. Sherman Smith.

SCHNEERER, WILLIAM F., Instructor in Engineering Drawing, Case Institute of Technology, Cleveland, Ohio. O. M. Stone, W. E. Nudd.

SCOFIELD, GORDON L., Associate Professor of Mechanical Engineering, School of Mines, Rolla, Mo. C. L. Wilson, A. J. Miles.

SEULBERGER, F. GEORGE, Assistant Dean, Northwestern Technological Institute, Evanston, Ill. A. B. Bronwell, O. W. Eshbach.

SHOCKLEY, THOMAS D., Jr., Instructor in Engineering Drawing, Louisiana State University, Baton Rouge, La. D. P. Dixon, J. S. Comer.

SIEMON, STANLEY, R., Senior Lecturer, Chemical Engineering, Canterbury University College, Christchurch, N. Z. R. M. Boarts, H. F. Johnson.

SIMON, HERBERT A., Professor and Head, Industrial Mgt., Carnegie Institute of Technology, Pittsburgh, Pa. G. L. Bach, B. R. Teare, Jr.

SMITH, LEIGHTON B., Professor of Chemical Engineering, Tufts College, Medford, Mass. C. E. Tucker, H. C. Ries.

SMITH, THOMAS N., Professor of Engineering Administration, Michigan College of M. & T., Houghton, Mich. S. R. Price, A. C. Morrill.

SMITH, WAYLAND P., Instructor in Mechanical Engineering, Case Institute of Technology, Cleveland, Ohio. E. Laitala, W. A. Lynam.

SNELL, JOHN R., Professor and Head, Department of Civil Engineering, Michigan State College, East Lansing, Mich. M. F. Rogers, D. W. Ryckman.

SPALDING, SAMUEL C., JR., Assistant Professor of Chemical Engineering, University of Louisville, Louisville, Ky. H. H. Fenwick, R. I. Fields.

STANNARD, GEORGE E., Assistant Professor of Electrical Engineering, Worcester Polytechnic Institute, Worcester, Mass. T. H. Morgan, H. H. Newell.

STEVENS, JOHN A., Assistant Professor of Civil Engineering, University of Miami, Miami, Fla. M. I. Mantell, J. H. Clouse.

STOCK, ELDON M., Professor of Civil Engineering, Utah State Agricultural College, Logan, Utah. J. E. Christiansen, D. K. Fuhriman.

STOKEY, WILLIAM F., Assistant Professor of Mechanical Engineering, Carnegie Institute of Technology, Pittsburgh, Pa. C. M. Tyler, Jr., Walton Forstall, Jr.

STRUNK, GRANVILLE B., Instructor in Engineering Drawing and Descriptive Geometry, Stockton College, Stockton, Calif. W. J. Luzadder, H. E. Welch.

SWIFT, MARVIN H., Instructor in English and Psychology, General Motors Institute, Flint, Mich. R. E. Tuttle, C. A. Brown.

SYVERSON, ALDRICH, Associate Professor of Chemical Engineering, Ohio State University, Columbus, Ohio. J. H. Koffolt, L. D. Jones.

TEST, FREDERICK L., Assistant Professor of Mechanical Engineering, University of Rhode Island, Kingston, R. I. J. Parker, D. Bradbury.

THOMAS, HENRY E., Associate Professor of Engineering, Lowell Textile Institute, Lowell, Mass. M. Hindle, M. E. Gelinas.

THORSON, DONALD A., Assistant Professor of Civil Engineering. School of Mines, Rapid City, S. D. W. I. Mitchell, E. E. Clark.

TOOLES, CALVIN W., Assistant Professor of Civil Engineering, Virginia Polytechnic Institute, Blacksburg, Va. R. C. Brinker, T. W. Brockenbrough.

VAN STRIEN, DAVID O., Assistant Professor of Civil Engineering, Michigan State College, East Lansing, Mich. D. W. Ryckman, L. A. Smith.

WALDEN, DON W., Representative, International Textbook Company, Scranton, Pa. (Home address: 127 N. Greenwood Ave., Palatine, Ill.) R. E. Wilson, L. W. Tice.

WASHBURN, DOUGLAS H., Assistant Professor of English, Rensselaer Polytechnic In-

stitute, Troy, N. Y. C. H. Gray, F. Abbuhl.

WEAVER, WILLIAM H., Professor of Mechanical Engineering, University of Massachusetts, Amherst, Mass. G. A. Marston, M. E. Bates.

WESTHAFER, ROBERT L., Associate Professor of mathematics, New Mexico College of A. & M. A., State College, N. Y. A. M. Luken, M. A. Thomas.

WIEBELT, JOHN A., Instructor in Mechanical Engineering, Southern Methodist University, Dallas, Tex. R. M. Mattson, C. H. Shumaker.

WILEY, JAY W., Associate Professor of History, Economics, Government, Purdue University, Lafayette, Indiana. W. J. Luzadder, J. N. Arnold.

WILKINSON, BRUCE W., Shell Oil Fellow, Department of Chemical Engineering, Ohio State University, Columbus, Ohio. J. H. Koffolt, L. D. Jones.

WILLIAMS, WENTWORTH, Dean of Students Lowell Textile Institute, Lowell, Mass. M. Hindle, M. E. Gelinas.

WOODWORTH, FORREST M., Instructor in Engineering Drawing, University of Detroit, Detroit, Mich. S. Osborne, O. F. Heyden.

WORSHAM, LUDSON D., Vice President and Project Manager, The Ralph M. Parsons Co., Frederick, Md. W. R. Woolrich, A. B. Bronwell.

WYLIE, FRANK B., JR., Assistant Professor of Civil Engineering, University of Tennessee, Knoxville, Tenn.

Young Faculty Members . . . . .

PAPER COMPETITION

ELIGIBILITY: Members of ASEE not over 36 years of age in June, 1953.

AWARDS: First prize $200—Second prize $100.
Awards will be presented to recipients at the Banquet at the Annual Meeting of ASEE, University of Florida, June 25, 1953.

SUBJECT: Papers should deal with some constructive phase of improvement of engineering education. Participants are encouraged to select their own subject matter and titles within the broad framework of improvement of engineering education. In general, the papers should not be of a technical nature. The following are suggestions of the type of subject matter to consider:

a. How can the student learn to deal with new and unfamiliar situations with originality and well-ordered professional thinking?

b. What are the most important qualifications of undergraduate teachers of engineering?

JUDGING: Each Section will appoint its own judging committee and select one winning paper. The winning papers from the Sections will be reviewed by a national judging committee for the final awards.

SUBMISSION OF ENTRIES: Papers can be submitted to the following persons in the ASEE Section in which the participant resides:

Section	*Final Date*	*Submit Entry To:*
Allegheny	April 1, 1953	L. Zee Seltzer, West Virginia University, Morgantown, W. Va.
Missouri	April 1, 1953	F. H. Conrad, School of Mines, Rolla, Mo.
National Capital	March 23, 1953	L. K. Downing, Howard University, Washington, D. C.
New England	March 15, 1953	E. T. Donovan, University of New Hampshire, Durham, N. H.
North-Midwest	April 1, 1953	S. J. Chamberlain, Iowa State College, Ames, Iowa
Ohio	March 14, 1953	H. K. Justice, University of Cincinnati, Cincinnati, Ohio
Pacific-Northwest	March 15, 1953	J. P. Spielman, State College of Washington, Pullman, Wash.
Rocky Mountain	March 10, 1953	R. E. Leffel, University of Colorado, Boulder, Colo.
Southeastern	Feb. 27, 1953	M. Baker, University of Kentucky, Lexington, Ky.
Southwestern	April 2, 1953	R. D. Slonneger, University of Texas, Austin, Tex.
Upper New York	March 15, 1953	A. D. Taylor, 18 Campus Drive East, Snyder 21, N. Y.

The following Sections have not indicated a final date for entries, but papers submitted prior to March 15 will be considered:

Illinois-Indiana	—	H. A. Moench, Rose Polytechnic Institute, Terre Haute, Ind.
Kansas-Nebraska	—	M. A. Durland, Kansas State College, Manhattan, Kans.
Michigan	—	C. C. Winn, Detroit Inst. of Technology, Detroit, Mich.
Middle Atlantic	—	W. B. Plank, Lafayette College, Easton, Pa.
Pacific-Southwest	—	C. E. Cherry, College of Marin, Kentfield, Calif.

Sections and Branches

The Fall Meeting of the **Middle Atlantic Section** of the ASEE was held at Manhattan College in New York City on December 6, 1952. Reverend Brother Bonaventure Thomas, President of Manhattan College, in welcoming the visitors suggested that they should strive as educators, not only to teach engineering fundamentals but to infiltrate those principles which are socially and morally good. Chairman W. B. Plank presided over this meeting whose topic was "The Role of Professionalism in Engineering Education." Speakers included E. J. Nunan, W. J. McCarthy and J. L. McManus. A second general session, with Reverend Brother Bernard presiding, was devoted to the topic "Transition—College to Training in Industry," presented by Dwayne Orton, assisted by C. S. Purnell and D. J. O'Connell. New Section officers include: Chairman, C. Bonilla; Vice-Chairman, C. Burrill; Council Representative, T. Saville.

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The thirty-third annual meeting of the **Kansas-Nebraska Section** convened on October 24, 1952 in the parlors of Plymouth Congregational Church of Lawrence, Kansas. M. A. Durland presided. W. R. Woolrich, President of ASEE, spoke on the subject "Should We Up-Grade the Engineering Profession to Higher Achievement Levels?" At the close of his address Dean Woolrich answered questions from the floor. The following officers were elected: Chairman, M. H. Barnard; Vice-Chairman, J. E. Ward; Secretary-Treasurer, P. G. Hausman; Council Representative, M. A. Durland. It was announced that the meeting for next year would be held at Kansas State College.

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The **Upper New York Section** of the ASEE held its seventh annual meeting at Alfred University on October 10 and 11, 1952. The General Session on Saturday morning was highlighted by a panel discussion on the topic "The Trend of Engineering Education in 1952." Speakers were: J. Seidlin, R. R. Dry, S. C. Hollister, N. L. Freeman, M. M. Boring and C. V. Newsom. A. B. Bronwell, National Secretary of ASEE, and M. M. Boring, National Vice-President, attended the meeting. The following officers were elected: Chairman, F. E. Almstead; Vice-Chairman, N. A. Christensen; Secretary-Treasurer, A. D. Taylor. The next annual meeting of the Section, with the Rochester Institute of Technology serving as host for the Technical Institute group, will be held in October, 1953.

In the News

"Who's Who in Engineering" announces the beginning of the compilation of the 7th edition, the first revision since 1948. The Advisory Committee of Engineers Joint Council on the publication met with the editor and publisher recently and drew up the minimum qualifications for inclusion in the volume.

The method of revision that will be followed includes the resubmission of their material to all those recorded in the 6th edition; the extension of invitations to supply data to a large list of engineers who have been variously recommended for the volume during the four years since the appearance of the 6th edition; the extension of invitations to engineers in all branches of the profession not now included, whose activities are indicative of the quality of their professional accomplishments; the issuance of invitations to engineers recommended by institutions and organizations with which they have been identified.

The Advisory Committee of Engineers Joint Council is composed of: A. A. Potter, Chairman, Dean of Engineering, Purdue University; George W. Bailey, Seretary, The Institute of Radio Engineers; Prof. A. B. Bronwell, Secretary, American Society for Engineering Education; Col. W. N. Carey, Secretary, American Society of Civil Engineers; Col. C. E. Davies, Secretary, The American Society of Mechanical Engineers; H. H. Henline, Secretary, American Institute of Electrical Engineers; S. Paul Johnston, Director, Institute of Aeronautical Sciences; Paul H. Robbins, Executive Director, National Society of Professional Engineers; E. H. Robie, Secretary, American Institute of Mining and Metallurgical Engineers; S. L. Tyler, Secretary, American Institute of Chemical Engineers; John A. C. Warner, Secretary, Society of Automotive Engineers; and L. Austin Wright, Secretary, Engineering Institute of Canada.

The importance of the publication to the profession and to the country at large, a point in which there is general concurrence, is stressed. The volume is produced under careful editorship, with ready acceptance by the publisher of workable suggestions from professional groups upon coverage.

The minimum qualifications for inclusion referred to above are as follows:

1. Engineers of at least ten years active practice, at least five years of which have been in responsible charge of important engineering work.

2. Teachers of engineering subjects in colleges or schools of accepted standing who have taught such subjects for at least ten years, at least five years of which have been in responsible charge of a major engineering course in such college or school.

College Notes

Announce National Collegiate-Industry-Government Conference on Instrumentation

The Electrical Engineering Department of **Michigan State College**, in cooperation with the National Science Foundation, the National Bureau of Standards, the Instrument Society of America, and the American Society for Engineering Education, announces an invitational National Collegiate-Industry-Government Conference on Instrumentation to be held on its campus, March 19–20, 1953.

The Conference is being called in recognition of the growing importance and potential of instrumentation in research and production, and to the national defense. The objectives of the Conference are:

a. To relate the role and needs of Instrumentation in production and research to college interests and responsibilities,

b. To review current Instrumentation activities in the colleges,

c. To suggest specific activities the colleges might undertake in this field,

d. To suggest specific ways by which Industry might assist the colleges in these activities.

Participating in the program and representing the sponsoring groups will be Paul Klopsteg, Director of the Mathematical, Engineering and Physical Sciences Div. of the National Science Foundation, A. V. Astin, Director of the National Bureau of Standards, Porter Hart, President of the Instrument Society of America, and E. A. Walker, Dean of Engineering at Pennsylvania State College.

Others on the program include: from industry, G. M. Rassweiler, Assistant Chief, Physics-Instrumentation Lab., General Motors Technical Center, J. B. MacMahon, Republic Flow Meters Company, George Muschamp, Vice-President, Brown Instrument Company, R. T. Sheen, Vice-President, Milton Roy Company; from Government, W. A. Wildhack, Chief, Office of Basic Instrumentation, N. B. S.; from the colleges, J. D. Trimmer, University of Tennessee, R. W. Jones, Northwestern University, C. S. Draper, M.I.T., H. C. Roberts, University of Illinois, D. P. Eckman, Case Institute and R. J. Jeffries and M. Muelder, Michigan State College.

Educational and Industrial administrators and others interested in the field of Instrumentation who would like additional information concerning the Conference should write to Professor R. J. Jeffries, Department of Electrical Engineering, Michigan State College, East Lansing, Michigan, at once, as attendance will be limited.

* * *

The departments of electrical engineering and physics of the **University of Illinois** College of Engineering, in cooperation with several leading companies in the electronics industry, will conduct a Summer School on Semiconductors and Transistor Electronics at Urbana, Ill., June 22–July 17, 1953. Courses will be offered in three areas—a general survey of semiconductors, physics of transistors, and transistor circuits. Lecturers will include outstanding scientists from industrial laboratories as well as regular University of

Illinois staff members. The school will be part of the Summer Session of the University, so that graduate-level academic credit can be given if desired. Inquiries should be addressed to the Department of Electrical Engineering, University of Illinois, Urbana, Ill.

* * *

Dean S. S. Steinberg, chairman of the ASEE Committee on International Relations and Dean of Engineering of the **University of Maryland**, attended the Inter-American Convention of the American Society of Civil Engineers at San Juan, Puerto Rico. He will represent the President's Conference on Industrial Safety, of which he is chairman of the Committee on Education. He will present a paper on "Safety Integration into Engineering Curricula."

* * *

The appointment of Dr. Ely Mencher, formerly Senior Field Geologist and Research Geologist with the Socony Vacuum Oil Company of Venezuela, as Associate Professor of Geology in the Department of Geology and Geophysics at the **Massachusetts Institute of Technology** has been announced. At M.I.T. Dr. Mencher will conduct courses in Stratigraphy and Petroleum Geology and will continue his research on the Geology of South America.

* * *

Dr. Herschel H. Cudd has been appointed Acting Director of **Georgia Tech's** State Engineering Experiment Station. He will assume the duties of Dr. Gerald A. Rosselot, former Director, who recently resigned. Dr. Cudd, who has served as head of the Station's Chemical Sciences Division since 1950, possesses a broad background of industrial research experience, including employment with du Pont's Rayon Technical Division, International Minerals and Chemicals Corp., and West Point Manufacturing Company. Prior to joining the Station's staff, Dr. Cudd was director of West Point's Lantuck Division. Dr. Cudd received his B.S. in Chemistry from Texas A. & I. in 1933 and his Ph.D. in Physical Chemistry from the University of Texas in 1941.

* * *

The Daniel and Florence Guggenheim Foundation will grant a total of $36,000 for 1953 Guggenheim Jet Propulsion Fellowships for graduate study in rocket and jet propulsion engineering at the **California Institute of Technology** and at Princeton University.

* * *

New head of the department of theoretical and applied mechanics in the **University of Illinois** college of engineering is Professor Thomas J. Dolan. The board of trustees named him on Nov. 28 as successor to Professor Fred B. Seely, who has reached retirement age. Prof. Dolan is president of the Society for Experimental Stress Analysis, chairman of an American Society for Testing Materials committee on fatigue, a consultant for the National Science Foundation, and latest winner of the Templin award of the ASTM. He served as a delegate to the World Metallurgical Congress in 1951, and as a participant in the Stockholm conference on the fatigue of metals in that same year.

* * *

Cornell University has set up a special 5-year curriculum in agricultural engineering and will grant a new professional degree—bachelor of agricultural engineering—to students who successfully complete the work.

* * *

New York University will initiate a program of graduate courses in transportation engineering with the academic term beginning in February, 1953. The new program will emphasize modern highway planning, design, and construction; traffic engineering; and airport design. The course offerings are primarily intended for persons holding undergraduate degrees in

Civil Engineering. Each course may be taken as a portion of a program leading to an advanced degree, or as a single course by a qualified special student. Completion of the entire series constitutes a measure of specialization in this phase of civil engineering.

* * *

Graduate study in technical writing is to be offered by **Rensselaer Polytechnic Institute** beginning with the next college year. The degree of master of science is to be awarded on satisfactory completion of two semesters of work. Courses are designed to develop clear, grammatical and interesting writing on technical subjects. The English department is to direct the program.

The Rensselaer master's degree in technical writing is believed to be the first offered in this particular field.

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Engineering Enrollments and Degrees, 1952 *

By ROBERT C. STORY and HENRY H. ARMSBY **

The engineering enrollment picture for the fall of 1952 is extremely encouraging. After successive yearly declines from the high point of 244,390 in 1947, engineering enrollment has taken a decided upward turn. The 158,518 students currently enrolled in engineering schools accredited by the Engineers' Council for Professional Development represent an increase of 7.3 per cent over the number enrolled in the fall of 1951. The increase in total enrollment in all higher educational institutions for the same period was 1.5 per cent. Since engineering enrollment is made up almost exclusively of men, it is perhaps more appropriate to contrast the 7.3 per cent increase in engineering enrollment with the 0.8 per cent decrease in total male enrollment in all higher educational institutions.

Colleges and universities across the Nation experienced increases in new students this fall unparalleled since the tremendous wave of new students in the fall of 1946. In the engineering schools the percentage increase in new students was more than twice what it was for all institutions (34.3 vs. 13.7). The 1952 freshman class, numbering 45,854, is the 4th largest class ever to enter the engineering schools. Only in 1946, 1947, and 1948 has the number been exceeded. The contrast is even more striking when one compares the circumstances prevailing today with those of the immediate post-war years. The enrollment bulge following World War II was the result of a sudden releasing of the pent-up demand for education which had been held in check during the war. Today this situation exists only in very small measure in the return of the Korean veterans, who presently comprise a tiny segment of the college population.

While the evidence suggests that a higher percentage of young people are entering college, the dimension is not sufficiently large to account for the exceptional increase in freshmen engineering students. In the first place, a greater proportion of entering students are choosing engineering in preference to other curricula. This year 8.5 per cent of all freshmen were enrolled in engineering schools as compared to 7.2 per cent in 1951 and 5.7 per cent in 1950. The prewar figure was about 8 per cent. The elements which are probably most closely related to the selection of engineering by so many freshmen are: (1) The widely publicized need for technical and scientific personnel, and the relatively high rates of pay new engineering graduates are receiving, (2) the opportunity for military reserve training with attendant commissions upon graduation, and (3) the fact that postponement of military service until graduation is more socially palatable in the case of scientific and technical training than in other areas of study.

The large increase in the number of freshmen engineering students enrolled this fall will have a decided effect on the trend in the number of graduates. Assuming normal progression, this year's

* All engineering data appearing in the text of this report are restricted to ECPD accredited schools. A report covering all engineering schools, regardless of ECPD accreditation, will shortly be issued by the U. S. Office of Education.

** In the U. S. Office of Education, Federal Security Agency, Mr. Story is Head, Statistical Services Unit, Research and Statistical Standards Section; and Mr. Armsby is Chief for Engineering Education, Division of Higher Education.

entering class will yield about 29,000 graduates in 1956. In the intervening years, however, the number of graduates will continue to drop, reaching a low of somewhat less than 20,000 in 1954. The present shortage of civilian engineers is apt to grow more acute in the years immediately ahead as fewer and fewer engineering students complete their training. Moreover, it should be remembered that many of those who do graduate will be going directly into the military service.

The number of undergraduate engineering students has increased for the first time since 1946. The 138,170 enrolled in the fall of 1952 represent an increase of 7.6 per cent over the previous year's enrollment.

Of the undergraduate enrollment, freshmen account for 33 per cent; sophomores, 19 per cent; juniors, 16 per cent; and seniors, 17 per cent. About 2 per cent are 5th year students in 5-year curricula, and the remaining 13 per cent are part-time and evening students. The latter category of students has increased steadily as the composition of the student body has changed from predominately veteran students to nonveteran students.

About 55 per cent of all undergraduate engineering students are enrolled in 3 curricula—mechanical, electrical, and civil. Of these three, 21.2 per cent were enrolled in mechanical, 19.3 per cent in electrical, and 14.7 per cent in civil. The tendency of institutions not to assign freshmen to specialized curricula is increasingly reflected in the current statistics. This fall 92 schools reported unclassified students as compared to 84 schools in the fall of 1951.

The number of male students who received their undergraduate engineering degrees in 1951–52 is down 28.3 per cent from the previous year. This compares with the decline of 18.7 per cent in first degrees granted to male students in all institutions. Of all first degrees granted to men students 11.9 per cent were in engineering. In the previous year 13.5 per cent of all first degrees to men were in engineering.

The distribution of first degrees among the three principal engineering curricula was as follows: Mechanical, 6823; electrical, 5876; and civil, 4917. The number of graduates in each of the three curricula is considerably lower than in the previous year. In mechanical engineering the number of degrees decreased 29.0 per cent. About 32 per cent fewer were graduated in electrical engineering, and 24 per cent fewer were graduated in civil engineering.

The increase in graduate enrollment has continued unabated. In the fall of 1952, 5.9 per cent more students were enrolled for the master's or other pre-doctoral degree than in 1951. The number of students enrolled as candidates for the doctor's degree increased 1.9 per cent. About 57 per cent of the students working toward the master's degree were evening students. In contrast, a considerably smaller percentage (22.8) of the students working for their doctorates were evening students.

The increase in the number of graduate students is a reflection of the demand of industry for persons with training beyond the baccalaureate degree. This is especially evident when one considers the high proportion of the candidates for master's degrees who are enrolled as evening students. Undoubtedly, most of these students are employed engineers who have recognized the necessity for advanced training either to improve their positions or to better their understanding of the more complex engineering processes which are developing today.

While the number of graduate students in engineering has increased, the per cent of all engineering students who are enrolled in graduate work (12.8) has decreased. In the fall of 1951 the per cent was 13.1. For the college population as a whole, about 10 per cent are graduate students.

More than 30 per cent of all engineering graduate students are taking their training in electrical engineering; mechanical engineering accounts for about 17 per cent; while approximately 11 per cent are enrolled in chemical engineering.

Master's degrees in engineering declined 19.5 per cent in 1951–52 from the previous year. The comparable decrease in all master's degrees conferred was 5.8 per cent. The number of doctor's degrees in engineering remained exactly the same as in 1951, while the percentage increase for all doctor's degrees was approximately 5 per cent.

The data contained in this report are based on a survey of engineering schools and colleges made in October 1952, under the joint sponsorship of the U. S. Office of Education and the American Society for Engineering Education. In accordance with an agreement reached by the joint committee of the Office of Education and the ASEE, all institutions listed in the Office of Education Directory of Higher Education,[1] which reported that they conferred degrees in engineering during 1951–52,[2] were requested to supply data. Eight Canadian institutions were also invited to participate in the study. Reports were received from all institutions accredited by the ECPD, from 44 other U. S. institutions, and from the 8 Canadian institutions.

[1] Education Directory, Part III, Higher Education, 1951–52.

[2] Earned Degrees Conferred in Higher Educational Institutions, 1951–52, Circular No. 360, U. S. Office of Education.

As proposed by the joint ASEE and Office of Education Committee and approved by the ASEE general council, the tabulations in this report list individually only the ECPD accredited institutions (eligible for active membership in the ASEE) but contain data for the other U. S. institutions as a group and for the Canadian institutions as a group.

Definition of Items:

Period covered: Engineering schools were asked to report student enrollment as of October 6, 1952. A few institutions, because of late opening, were unable to report before November. Degree data are for the period July 1, 1951 to June 30, 1952.

Undergraduate students: Institutions were requested to report by class level only those students enrolled definitely as candidates for an engineering degree. "Part-time students" (both day and evening) may include degree candidates as well as students who are not working toward a degree.

Graduate students: Institutions were requested to "Report all students who have been admitted to formal graduate courses—regardless of the number of credit hours carried by the students, and regardless of whether the student's work is administered by the engineering college or the graduate school."

PRE-WAR AND POST-WAR COMPARISON OF ENGINEERING COLLEGE ENROLLMENTS

(for United States only)

Undergraduate Enrollment

Year	Freshman	Sophomore	Junior	Senior	5th Year	Part Time and Evening	Total	No. of First Degrees
1940	33,175	24,242	20,120	16,310	985	14,079	108,911	11,358 (1939–40)
1947	57,507	71,615	48,227	32,369	1,846	18,616	230,180	18,592 (1946–47)
1948	47,672	52,949	59,945	45,695	1,924	17,932	226,117	27,460 (1947–48)
1949*	36,508	35,648	41,695	50,991	2,326	13,478	180,646	41,793 (1948–49)
1950*	29,394	27,242	30,957	37,707	3,150	14,504	142,954	48,160 (1949–50)
1951*	34,147	23,408	24,757	27,820	2,946	15,289	128,367	37,904 (1950–51)
1952*	45,854	26,636	22,369	23,453	2,563	17,295	138,170	27,155 (1951–52)

Graduate Enrollment

	Master's Degrees and Other Pre-Doctoral Degrees					Doctor's Degrees				
Year	Full Time	Part Time	Evening	Total	Master's and Other Pre-Doctoral Degrees	Full Time	Part Time	Evening	Total	Doctor's Degrees
1940	2,003	980	1,599	4,582	1,318 (1939–40)	404	179	41	624	108 (1939–40)
1947	5,465	3,663	3,515	12,643	3,090 (1946–47)	704	784	79	1,567	127 (1946–47)
1948	6,138	2,348	4,882	13,368	4,303 (1947–48)	1,046	569	454	2,069	252 (1947–48)
1949*	6,277	4,056	4,746	15,079	4,783 (1948–49)	1,593	793	155	2,541	417 (1948–49)
1950*	8,150		7,425	15,575	4,865 (1949–50)	2,342		453	2,795	492 (1949–50)
1951*	6,878		9,574	16,452	5,134 (1950–51)	2,419		456	2,875	586 (1950–51)
1952*	7,422		9,996	17,418	4,132 (1951–52)	2,261		669	2,930	586 (1951–52)

	1940	1947	1948	1949	1950	1951	1952
Total college enrollment in U. S.	1,490,000	2,333,000	2,410,000	2,456,000	2,297,000	2,116,000	2,148,000
Engineering enrollment in U. S.	113,497	244,390	241,554	198,266*	161,324*	147,694*	158,518*
Per cent engineering to total	7.6%	10.5%	10.0%	8.0%*	7.0%*	7.0%*	7.4%*

* Includes only ECPD accredited institutions.

* Includes only ECPD accredited institutions.

Undergraduate Engineering Enrollment, by Curriculum, October 6, 1952

Engineering Curriculum	No. of Schools [1]	Total Number Enrolled for Their First Engineering Degree										No. of First Engineering Degrees Conferred 1951–52	
		1st yr.	2nd yr.	3rd yr.	4th yr.	5th yr. of 5-yr. Curriculum	5th yr. of Cooperative Program	Part-Time and Special Day Students	Evening Students	Total			
										Men	Women	Men	Women
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Schools accredited by ECPD:													
Aeronautical	47	1,554	930	670	686	15	25	76	147	4,083	20	687	7
Agricultural	32	345	280	266	311	21	—	7	—	1,230	—	334	—
Architectural	30	890	709	656	682	238	24	23	31	3,209	44	731	5
Ceramic	13	121	99	105	125	12	—	4	—	459	7	156	—
Chemical	107	3,822	2,804	2,263	2,375	135	189	32	1,084	12,649	55	2,734	9
Civil	137	5,323	4,497	3,969	4,406	189	206	169	1,524	20,228	55	4,911	6
Electrical	135	7,263	5,822	4,821	4,804	211	319	369	3,087	26,629	67	5,870	6
Engineering Mechanics	2	—	11	10	9	—	—	—	—	29	1	19	1
Engineering Physics	31	384	326	322	268	22	3	10	12	1,335	12	288	—
General Engineering	24	944	668	516	587	—	—	64	906	3,674	11	614	—
Geological	23	302	231	247	244	14	—	6	27	1,066	5	261	—
Industrial [2]	59	1,097	1,111	1,105	1,390	51	58	68	193	5,056	17	1,570	3
Mechanical	132	7,823	6,429	5,339	5,413	334	408	343	3,246	29,277	58	6,815	8
Metallurgical	46	508	458	542	585	18	27	7	117	2,252	10	577	1
Mining	30	246	232	260	344	16	—	4	11	1,113	—	371	—
Naval Arch. and Marine	3	37	54	50	49	—	—	2	—	192	—	57	—
Petroleum	22	1,149	674	627	696	11	—	5	87	3,246	3	642	—
Sanitary	8	35	20	33	32	—	—	—	11	130	1	32	—
Textile	5	195	145	128	117	—	—	—	—	584	1	97	1
Unclassified	92	13,535	911	131	23	—	—	141	5,383	19,933	191	45	—
Other	30	281	225	309	307	17	—	99	—	1,227	11	297	—
Total ECPD	149	45,854	26,636	22,369	23,453	1,304	1,259	1,429	15,866	137,601	569	27,108	47
Other U. S. Schools	44	5,777	3,583	2,642	2,511	311	191	181	2,714	17,878	32	3,126	5
All U. S. Schools	193	51,631	30,219	25,011	25,964	1,615	1,450	1,610	18,580	155,479	601	30,234	52
Canadian Schools	8	1,854	1,289	992	1,080	384	—	—	—	5,577	22	1,367	7
Grand Total (U. S. and Canada)	201	53,485	31,508	26,003	27,044	1,999	1,450	1,610	18,580	161,056	623	31,601	59

[1] This refers to the number of schools offering given curriculum. Such curriculum may or may not be specifically approved by ECPD.
[2] Includes administrative engineering, management engineering, etc.

Graduate Engineering Enrollment, by Curriculum, October 6, 1952

Engineering Curriculum	No. of Schools [1]	Number Enrolled in Work for the Master's Degree				No. of Master's Degrees Conferred in Eng'g 1951–52		Number Enrolled in Work for Other Post-Graduate Pre-Doctoral Degrees [2]				No. of Post-Grad. Degrees [2] Conferred in Eng'g 1951–52		Number Enrolled in Work for the Doctor's Degree				No. of Doctor's Degrees Conferred in Eng'g 1951–52	
		Day Students Full Time and Part Time	Evening and Special Students	Total				Day Students Full Time and Part Time	Evening and Special Students	Total				Day Students Full Time and Part Time	Evening and Special Students	Total			
				Men	Wo.	Men	Wo.			Men	Wo.	Men	Wo.			Men	Wo.	Men	Wo.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
ECPD accredited schools:																			
Aeronautical	38	368	361	725	4	220	1	37	—	37	—	18	—	111	31	141	1	24	—
Agricultural	25	140	—	140	—	70	—	—	—	—	—	—	—	14	—	14	—	5	—
Architectural	11	29	—	29	—	17	—	—	1	1	—	—	—	—	—	—	—	—	—
Ceramic	14	65	—	65	—	36	—	—	—	—	—	—	—	48	—	48	—	8	—
Chemical	82	775	999	1,762	12	538	2	5	—	5	—	—	—	467	76	541	2	159	—
Civil	94	931	917	1,842	6	570	1	14	—	14	—	14	1	166	82	247	1	43	—
Electrical	96	1,686	3,575	5,254	7	987	3	54	1	55	—	26	—	567	269	826	10	119	2
Engineering Mechanics	25	140	101	241	—	59	—	—	—	—	—	—	—	86	26	112	—	25	—
Engineering Physics	17	129	166	293	2	89	1	—	—	—	—	—	—	43	14	55	2	29	—
General Engineering	11	208	61	266	3	52	2	1	—	1	—	—	—	55	—	53	2	5	—
Geological	13	93	—	89	4	17	—	—	—	—	—	—	—	9	—	9	—	4	—
Industrial [3]	39	484	1,027	1,503	8	265	—	—	—	—	—	6	—	26	33	59	—	6	—
Mechanical	91	1,201	1,869	3,064	6	625	2	42	1	43	—	18	—	271	72	338	5	68	—
Metallurgical	41	265	294	558	1	133	1	1	1	2	—	2	—	219	43	262	—	53	—
Mining	19	48	—	48	—	30	—	—	—	—	—	—	—	7	—	7	—	3	—
Naval Arch. & Marine	3	22	—	22	—	6	—	80	—	80	—	38	—	—	—	—	—	—	—
Petroleum	17	171	21	192	—	74	—	2	—	2	—	—	—	5	—	5	—	3	—
Sanitary	14	76	10	86	—	56	—	—	—	—	—	2	—	30	—	30	—	7	—
Textile	3	23	—	23	—	10	—	—	—	—	—	—	—	—	—	—	—	—	—
Unclassified	14	53	343	391	5	21	1	1	—	1	—	—	—	12	—	12	—	—	—
Other	29	276	248	511	13	114	2	2	—	2	—	2	—	125	23	147	1	23	—
Total ECPD	116	7,183	9,992	17,104	71	3,989	16	239	4	243	—	126	1	2 261	669	2,906	24	584	2
Other U. S. Schools	2	6	115	121	—	9	—	—	—	—	—	—	—	—	—	—	—	—	—
All U. S. Schools	118	7,189	10,107	17,225	71	3,998	16	239	4	243	—	126	1	2,261	669	2,906	24	584	2
Canadian Schools	7	158	—	158	—	98	—	13	—	13	—	—	—	42	—	42	—	15	—
Grand Total (U. S. and Canada)	125	7,347	10,107	17,383	71	4,096	16	252	4	256	—	126	1	2,303	669	2,948	24	599	2

[1] This refers to the number of schools offering given curriculum. Such curriculum may or may not be specifically approved by ECPD.
[2] Other engineering degrees requiring work beyond the Master's degree, but less than the requirements for a Doctor's degree.
Includes administrative engineering, management engineering, etc.

[1] Includes engineering degrees requiring work beyond the Master's degree, but less than the requirements for a Doctor's degree.
Includes administrative engineering, management engineering, etc.

Total Undergraduate Engineering Enrollment, by School, October 6, 1952

Institutions	Total Number Enrolled for Their First Engineering Degree										No. of First Engineering Degrees Conferred 1951–52	
	1st yr.	2nd yr.	3rd yr.	4th yr.	5th yr. of 5-yr. Curriculum	5th yr. of Cooperative Program	Part-Time and Special Day Students	Evening Students	Total			
									Men	Women	Men	Women
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
ECPD accredited schools:												
Alabama												
Ala. Poly.	590	287	254	203	—	—	4	—	1,337	1	261	—
Univ. Ala.	240	125	96	111	—	—	11	474	1,048	9	137	—
Arizona												
Univ. Ariz.	269	161	137	154	—	—	15	—	730	6	141	—
Arkansas												
Univ. Ark.	171	99	89	122	—	—	3	5	487	2	109	—
California												
Calif. Tech.	177	82	64	60	—	—	—	—	383	—	72	—
Santa Clara	99	54	45	47	9	—	2	—	256	—	53	—
Stanford	317	162	94	96	—	—	—	—	669	—	128	—
Univ. Calif. (B.)	306	292	510	398	—	1	—	—	1,503	4	506	—
Univ. Calif. (L. A.)	260	201	211	122	—	—	—	—	792	2	152	—
Univ. Southern Calif.	130	116	254	307	—	—	14	523	1,342	2	295	2
U. S. Naval PG Sch.	—	—	197	151	—	—	—	—	348	—	140	—
Colorado												
Colo. A. & M.	192	101	87	101	—	—	—	—	479	2	65	—
Colo. Mines	294	174	175	199	—	—	—	—	841	1	222	—
Univ. Denver	75	61	80	70	—	3	15	15	319	—	103	1
Univ. Colo.	481	313	268	236	36	—	8	466	1,784	24	337	2
Connecticut												
U. S. Coast Guard	189	133	106	90	—	—	—	—	518	—	77	—
Univ. Conn.	308	190	106	122	—	—	—	—	726	—	137	—
Yale Univ.	—	224	181	177	—	—	—	—	582	—	200	—
Delaware												
Univ. Delaware	162	88	57	67	—	—	4	—	375	3	91	1
Florida												
Univ. Florida	660	285	131	160	—	—	—	—	1,236	—	166	—
Georgia												
Ga. Tech.	1,197	679	478	585	15	—	4	—	2,956	2	740	—
Idaho												
Univ. Idaho	196	124	86	83	—	—	1	—	489	1	72	—
Illinois												
Bradley	168	87	52	80	—	7	—	26	420	—	74	—
Ill. Inst. Tech.	254	241	286	334	—	23	27	3,456	4,550	71	557	—
Northwestern	209	167	143	125	—	123	41	—	806	2	124	1
Univ. Ill.	1,724	802	557	529	60	—	—	—	3,655	17	599	1

Total Undergraduate Engineering Enrollment, by School, October 6, 1952—*Continued*

Institutions	Total Number Enrolled for Their First Engineering Degree										No. of First Engineering Degrees Conferred 1951–52	
	1st yr.	2nd yr.	3rd yr.	4th yr.	5th yr. of 5-yr. Curriculum	5th yr. of Cooperative Program	Part-Time and Special Day Students	Evening Students	Total			
									Men	Women	Men	Women
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Indiana												
Notre Dame	529	282	244	185	4	—	—	—	1,244	—	188	—
Purdue	1,604	757	568	864	—	—	15	—	3,784	24	1,062	5
Rose Poly	108	69	41	60	—	—	—	—	278	—	77	—
Iowa												
Iowa St. Coll.	980	477	366	263	—	—	8	—	2,074	20	390	1
St. Univ. Iowa	122	71	71	78	—	—	—	—	339	3	83	—
Kansas												
Kan. St. Coll.	315	145	135	173	—	—	—	—	766	2	208	—
Kan. Univ.	331	224	182	209	—	—	2	—	939	9	184	—
Wichita	179	66	26	28	—	—	175	—	471	3	13	—
Kentucky												
Ky. Univ.	380	244	151	110	—	—	22	—	906	1	165	1
Louisville	134	88	68	65	101	—	2	—	458	—	101	—
Louisiana												
Louisiana Poly	271	107	64	48	—	—	3	—	493	—	70	—
Louisiana St. Univ.	583	170	205	232	—	—	—	—	1,188	2	230	1
Tulane Univ.	188	98	69	63	—	—	—	—	417	1	57	—
Maine												
Univ. Maine	295	163	127	132	1	—	4	—	713	9	161	—
Maryland												
Johns Hopkins	146	141	152	106	—	—	—	—	545	—	114	—
Md. Univ.	383	133	132	132	—	—	17	—	793	4	183	1
Massachusetts												
Harvard	—	41	26	13	—	—	—	—	80	—	28	—
Lowell Textile	71	53	52	45	—	—	—	—	220	1	47	1
Mass. Inst. Tech.	700	556	544	584	—	—	—	—	2,368	16	642	1
Mass. Univ.	237	127	74	67	—	—	—	—	502	3	89	—
Northeastern	640	364	331	290	—	342	—	—	1,956	11	418	2
Tufts	176	134	105	107	—	—	—	—	520	2	102	—
Worcester	187	159	155	147	—	—	—	—	648	—	155	—
Michigan												
Detroit Univ.	521	181	190	255	—	222	39	153	1,559	2	365	2
Mich. M. & T.	369	250	210	231	9	—	2	—	1,068	3	243	—
Mich. St. Coll.	479	224	301	255	—	—	—	45	1,304	—	283	—
Mich. Univ.	548	461	338	434	—	—	43	—	1,811	13	523	2
Wayne Univ.	346	220	225	215	—	—	72	—	1,068	10	134	—

Minnesota												
Univ. Minn.	585	364	317	281	281	—	27	—	1,850	5	378	—
Mississippi												
Miss. St. Coll.	244	118	111	76	4	—	—	—	553	—	118	—
Miss. Univ.	66	39	28	33	—	—	—	—	165	1	28	—
Missouri												
Mo. Mines	282	203	229	319	—	—	—	—	1,030	3	319	1
Mo. Univ.	300	150	102	121	—	—	—	—	673	—	244	—
St. Louis Univ.	131	89	80	77	—	—	—	—	375	2	93	1
Wash. Univ. (St. L.)	247	144	139	160	—	—	—	—	685	5	189	1
Montana												
Mont. St. Coll.	192	120	51	108	—	—	—	—	471	—	104	—
Mont. Mines	96	58	41	55	—	—	—	—	250	—	38	—
Nebraska												
Nebr. Univ.	342	160	131	115	—	—	18	—	764	2	158	—
Nevada												
Nevada Univ.	75	47	40	24	—	—	—	—	186	—	35	—
New Hampshire												
Dartmouth	163	87	34	40	—	—	—	—	324	—	18	—
New Hamp. Univ.	187	94	71	78	—	—	3	—	431	2	88	—
New Jersey												
Newark	340	258	208	218	—	—	—	1,090	2,095	19	279	—
Princeton	180	144	105	100	—	—	—	—	529	—	98	—
Rutgers	168	111	69	72	—	—	2	—	417	5	110	—
Stevens	273	179	137	196	—	—	—	—	785	—	183	—
New Mexico												
N. Mex. A. & M.	169	70	57	50	—	—	—	90	434	2	54	—
N. Mex. Univ.	177	105	71	98	—	—	3	49	498	5	107	2
New York												
Alfred	62	36	37	27	—	—	3	—	161	4	31	—
Brooklyn Poly.	407	284	236	249	—	—	—	2,014	3,188	2	467	—
Clarkson	256	206	127	156	—	—	—	—	745	—	235	—
City Coll. of N. Y.	1,139	542	358	430	—	—	—	867	3,308	28	429	2
Columbia	—	—	108	101	—	—	—	—	206	3	153	2
Cooper Union	107	121	61	62	—	—	—	370	716	5	101	1
Cornell	456	363	280	256	248	—	—	—	1,590	13	275	1
Manhattan	293	264	135	118	—	—	—	—	810	—	162	—
N. Y. Univ.	333	281	260	290	—	—	3	1,111	2,268	10	440	—
Pratt	71	47	42	41	—	—	—	—	198	3	74	—
Rensselaer	549	471	422	554	—	—	8	182	2,163	23	667	—
Rochester	87	56	38	37	—	—	—	—	218	—	50	—
Syracuse	178	115	96	149	—	—	—	—	538	—	181	—
Union Coll.	133	60	39	35	—	—	—	—	267	—	40	—
Webb	18	18	17	14	—	—	—	—	67	—	9	—
North Carolina												
Duke Univ.	173	101	96	56	—	—	—	—	426	—	63	—
N. C. St. Coll.	710	347	229	329	9	—	—	—	1,624	—	272	—

Total Undergraduate Engineering Enrollment, by School, October 6, 1952—*Continued*

Institutions	Total Number Enrolled for Their First Engineering Degree										No. of First Engineering Degrees Conferred 1951–52	
	1st yr.	2nd yr.	3rd yr.	4th yr.	5th yr. of 5-yr. Curriculum	5th yr. of Cooperative Program	Part-Time and Special Day Students	Evening Students	Total			
									Men	Women	Men	Women
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
North Dakota												
N. Dak. Ag. Coll.	182	124	81	70	—	—	—	—	457	—	83	—
N. Dak. Univ.	155	92	58	51	—	—	—	—	356	—	52	—
Ohio												
Akron	161	57	35	37	—	40	—	44	373	1	50	—
Case Inst.	370	241	249	237	—	—	9	186	1,289	3	298	—
Cincinnati	372	218	218	214	—	230	—	1,797	3,046	3	260	1
Fenn	112	69	52	14	—	86	3	742	1,078	—	147	1
Ohio St. Univ.	694	383	275	299	269	—	18	264	2,192	10	381	—
Ohio Univ.	225	86	63	99	—	—	—	—	470	3	137	—
Toledo	208	115	95	103	—	—	20	581	1,119	3	110	—
Univ. Dayton	224	42	32	39	—	—	8	—	344	1	41	—
Oklahoma												
Okla. A. & M.	613	249	240	253	36	—	3	—	1,394	—	169	—
Okla. Univ.	634	378	323	351	25	—	1	—	1,701	11	380	1
Tulsa	187	122	105	117	—	—	13	119	663	—	120	—
Oregon												
Oregon State	296	177	158	183	—	—	—	—	814	—	198	—
Pennsylvania												
Bucknell	105	55	53	62	—	—	—	—	272	3	75	—
Carnegie	327	231	237	232	—	—	7	562	1,588	8	264	1
Drexel	451	276	218	190	—	179	14	—	1,324	4	225	—
Lafayette	199	92	87	127	—	—	—	—	505	—	131	—
Lehigh	571	374	302	284	—	—	—	—	1,531	—	312	—
Pa. St. Coll.	1,018	587	437	490	—	—	15	—	2,537	10	539	—
Pittsburgh	304	208	243	252	—	—	224	325	1,552	4	354	—
Swarthmore	29	25	14	18	—	—	—	—	84	2	22	1
Univ. Pa.	120	71	72	72	—	—	—	—	335	—	104	—
Villanova	215	97	65	83	13	—	—	—	473	—	111	—
Rhode Island												
Brown	130	38	48	37	—	—	—	—	251	2	41	—
R. I. University	152	86	87	81	—	—	—	—	401	5	97	—

South Carolina												
Citadel	176	103	67	54	—	—	—	—	400	—	58	—
Clemson	505	224	198	153	—	—	—	—	1,080	—	190	—
S. C. Univ.	224	89	65	59	—	—	—	—	434	3	61	—
South Dakota												
S. Dak. Mines	224	59	58	91	—	—	—	—	432	—	87	—
S. Dak. St. Coll.	171	62	28	44	—	—	—	—	305	—	48	—
Tennessee												
Tenn. Univ.	397	217	184	126	—	—	—	—	924	—	152	—
Vanderbilt	165	140	86	87	—	—	—	—	473	5	70	1
Texas												
A. & M. Coll. Texas	1,007	609	393	421	48	—	31	—	2,509	—	499	—
Rice	159	111	67	68	55	—	—	—	454	6	49	—
Southern Meth.	129	64	50	59	60	—	23	—	384	1	65	—
Tex. Coll. A. & I.	100	69	30	21	—	—	—	—	220	—	24	—
Tex. Tech. Coll.	352	193	161	185	—	—	—	—	886	5	167	—
Tex. Western	116	52	53	59	—	—	—	78	358	—	37	—
Tex. Univ.	446	427	382	413	—	—	—	—	1,663	5	313	2
Univ. Houston	530	259	261	348	2	—	—	—	1,394	6	165	1
Utah												
Utah Ag. Coll.	107	70	65	61	—	—	—	—	303	—	53	—
Utah Univ.	433	140	143	164	—	—	9	—	889	—	121	—
Vermont												
Norwich	94	78	36	24	—	—	1	—	233	—	44	—
Vermont Univ.	94	62	49	40	—	—	6	—	249	2	41	—
Virginia												
Va. Mil. Inst.	164	136	75	83	—	—	—	—	458	—	86	—
Va. Poly.	538	305	284	298	2	—	—	—	1,425	2	357	—
Va. Univ.	199	82	63	66	—	—	2	—	411	1	80	—
Washington												
Wash. St. Coll.	250	100	124	132	16	—	—	—	621	1	148	—
Wash. Univ.	612	266	239	297	—	3	—	—	1,414	3	258	1
West Virginia												
W. Va. Univ.	216	167	140	89	—	—	1	10	620	3	163	—
Wisconsin												
Marquette	301	219	160	151	—	—	—	222	1,048	5	195	—
Univ. Wisconsin	835	382	292	378	—	—	—	—	1,882	5	346	—
Wyoming												
Wyoming Univ.	180	115	61	66	—	—	5	—	425	2	84	—
Dist. of Columbia												
Catholic Univ.	79	55	66	64	—	—	21	—	285	—	100	—
Geo. Wash. Univ.	66	32	33	25	—	—	371	—	522	5	92	—
Howard Univ.	88	25	27	29	—	—	1	—	170	—	34	1
Alaska												
Univ. Alaska	19	23	12	12	1	—	—	—	67	—	10	—
Hawaii												
Univ. Hawaii	145	103	72	46	—	—	3	—	363	6	47	—
Total ECPD Schools	45,854	26,636	22,369	23,453	1,304	1,259	1,429	15,866	137,601	569	27,108	47

Total Graduate Engineering Enrollment, by School, October 6, 1952

Institutions	Number Enrolled in Work for the Master's Degree				No. of Master's Degrees Conferred in Eng'g 1951–52		Number Enrolled in Work for Other Post-Graduate Pre-Doctoral Degrees[1]				No. of Post-Grad. Degrees[1] Conferred in Eng'g 1951–52		Number Enrolled in Work for the Doctor's Degree				No. of Doctor's Degrees Conferred in Eng'g 1951–52	
	Day Students Full Time and Part Time	Evening and Special Students	Total				Day Students Full Time and Part Time	Evening and Special Students	Total				Day Students Full Time and Part Time	Evening and Special Students	Total			
			Men	Wo.	Men	Wo.			Men	Wo.	Men	Wo.			Men	Wo.	Men	Wo.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
ECPD accredited schools:																		
Alabama																		
Ala. Poly.	19	—	19	—	5	—	—	—	—	—	—	—	—	—	—	—	—	—
Univ. Ala.	9	—	9	—	11	—	—	—	—	—	—	—	—	—	—	—	—	—
Arizona																		
Univ. Ariz.	14	56	69	1	8	—	—	—	—	—	—	—	—	—	—	—	—	—
Arkansas																		
Univ. Ark.	14	17	31	—	9	—	—	—	—	—	—	—	—	—	—	—	—	—
California																		
Calif. Tech.	70	—	70	—	64	—	49	—	49	—	19	—	56	—	56	—	16	—
Stanford	183	—	183	—	93	—	25	—	25	—	20	—	50	—	50	—	23	—
Univ. Calif. (B)	162	—	162	—	94	1	9	—	9	—	6	—	66	—	66	—	18	—
Univ. Calif. (L. A.)	172	—	169	3	19	2	1	—	1	—	—	—	52	—	50	2	4	—
Univ. Southern Calif.	184	—	184	—	49	—	16	—	16	—	—	—	12	—	12	—	2	—
U. S. Naval PG Sch.	59	—	59	—	34	—	—	—	—	—	—	—	—	—	—	—	—	—
Colorado																		
Colo. A. & M.	14	—	14	—	8	—	—	—	—	—	—	—	2	—	2	—	—	—
Colo. Mines	48	3	51	—	16	—	—	—	—	—	—	—	26	—	26	—	11	—
Univ. Denver	8	—	8	—	7	—	—	—	—	—	—	—	—	—	—	—	—	—
Univ. Colo.	37	109	146	—	25	—	—	—	—	—	1	1	6	—	6	—	2	—
Connecticut																		
Univ. Conn.	12	155	167	—	11	—	—	—	—	—	—	—	—	—	—	—	—	—
Yale Univ.	57	—	57	—	49	1	4	—	4	—	—	—	52	—	52	—	8	—
Delaware																		
Univ. Delaware	—	193	192	1	28	—	—	—	—	—	—	—	21	—	21	—	2	—
Florida																		
Univ. Florida	36	—	35	1	42	—	—	—	—	—	—	—	14	—	14	—	1	—

Georgia																		
Ga. Tech.	131	—	131	—	52	—	—	—	—	—	—	—	26	—	26	—	5	—
Idaho																		
Univ. Idaho	8	—	8	—	5	—	—	—	—	—	—	—	—	—	—	—	—	—
Illinois																		
Bradley	—	10	10	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Ill. Inst. Tech.	147	644	790	1	78	—	—	—	—	—	—	—	51	78	125	4	15	—
Northwestern	38	64	102	—	43	—	—	—	—	—	—	—	45	3	48	—	10	—
Univ. Ill.	207	—	204	3	148	—	—	—	—	—	—	—	171	—	171	—	26	—
Indiana																		
Notre Dame	34	12	46	—	13	—	—	—	—	—	—	—	9	—	9	—	4	—
Purdue	223	1	224	—	134	1	—	—	—	—	—	—	89	—	89	—	33	—
Rose Poly.	—	1	1	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—
Iowa																		
Iowa St. Coll.	60	—	60	—	37	—	—	—	—	—	—	—	53	—	53	—	15	—
St. Univ. Iowa	54	1	53	2	29	—	—	—	—	—	—	—	26	—	26	—	12	—
Kansas																		
Kan. St. Coll.	26	—	26	—	30	—	—	—	—	—	—	—	12	—	12	—	—	—
Kan. Univ.	32	—	32	—	16	—	—	1	1	—	1	—	3	—	3	—	1	—
Wichita	16	—	16	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—
Kentucky																		
Ky. Univ.	23	—	23	—	15	—	—	—	—	—	—	—	2	—	2	—	—	—
Louisville	18	36	54	—	6	—	—	—	—	—	—	—	—	—	—	—	—	—
Louisiana																		
Louisiana St. Univ.	28	59	87	—	29	—	—	—	—	—	—	—	2	—	2	—	2	—
Tulane Univ.	9	—	4	—	4	—	—	—	—	—	—	—	—	—	—	—	—	—
Maine																		
Univ. Maine	4	—	4	—	7	—	—	—	—	—	—	—	—	—	—	—	—	—
Maryland																		
Johns Hopkins	89	18	107	—	24	—	—	—	—	—	—	—	49	—	49	—	12	—
Md. Univ.	363	48	410	1	33	—	1	—	1	—	—	—	29	4	33	—	1	—
Massachusetts																		
Harvard	95	13	108	—	45	1	—	—	—	—	2	—	74	—	74	—	20	—
Lowell Textile	6	—	6	—	8	—	—	—	—	—	—	—	—	—	—	—	—	—
Mass. Inst. Tech.	606	—	605	1	374	1	133	—	133	—	63	—	288	—	288	—	71	—
Mass. Univ.	3	6	9	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—
Northeastern	—	580	580	—	8	—	—	—	—	—	—	—	—	—	—	—	—	—
Worcester	12	—	12	—	7	—	—	—	—	—	—	—	—	—	—	—	—	—
Michigan																		
Mich. M. & T.	18	—	18	—	9	—	—	—	—	—	6	—	—	—	—	—	—	—
Mich. St. Coll.	77	3	80	—	18	—	—	—	—	—	—	—	10	—	10	—	4	—
Mich. Univ.	265	—	264	1	182	—	1	—	1	—	—	—	132	—	131	1	32	1
Wayne Univ.	159	—	157	2	8	—	—	—	—	—	—	—	—	—	—	—	—	—

Total Graduate Engineering Enrollment, by School, October 6, 1952—*Continued*

Institutions	Number Enrolled in Work for the Master's Degree				No. of Master's Degrees Conferred in Eng'g 1951–52		Number Enrolled in Work for Other Post-Graduate Pre-Doctoral Degrees[1]				No. of Post-Grad. Degrees[1] Conferred in Eng'g 1951–52		Number Enrolled in Work for the Doctor's Degree				No. of Doctor's Degrees Conferred in Eng'g 1951–52	
	Day Students Full Time and Part Time	Evening and Special Students	Total				Day Students Full Time and Part Time	Evening and Special Students	Total				Day Students Full Time and Part Time	Evening and Special Students	Total			
			Men	Wo.	Men	Wo.			Men	Wo.	Men	Wo.			Men	Wo.	Men	Wo.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
Minnesota																		
Univ. Minn.	157	48	204	1	88	—	—	3	3	—	2	—	109	—	108	1	10	—
Mississippi																		
Miss. St. Coll.	3	—	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Miss. Univ.	3	—	3	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—
Missouri																		
Mo. Mines	40	—	40	—	35	—	—	—	—	—	—	—	11	—	11	—	—	—
Mo. Univ.	18	—	18	—	38	—	—	—	—	—	—	—	6	—	6	—	2	—
St. Louis Univ.	5	122	127	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—
Wash. Univ. (St. L.)	155	—	155	—	29	—	—	—	—	—	—	—	42	—	42	—	6	—
Montana																		
Mont. St. Coll.	9	—	9	—	18	—	—	—	—	—	—	—	—	—	—	—	1	—
Mont. Mines	7	—	7	—	5	—	—	—	—	—	—	—	—	—	—	—	—	—
Nebraska																		
Nebr. Univ.	11	—	11	—	5	—	—	—	—	—	1	—	—	—	—	—	—	—
New Hampshire																		
Dartmouth	16	—	16	—	20	—	—	—	—	—	—	—	—	—	—	—	—	—
New Hamp. Univ.	6	—	6	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—
New Jersey																		
Newark	—	590	586	4	87	—	—	—	—	—	—	—	—	—	—	—	—	—
Princeton	76	—	76	—	53	—	—	—	—	—	—	—	22	—	22	—	4	—
Rutgers	19	135	154	—	22	1	—	—	—	—	—	—	17	—	17	—	—	—
Stevens	—	1,210	1,200	10	154	—	—	—	—	—	—	—	—	10	10	—	—	—
New Mexico																		
N. Mex. A. & M.	—	46	46	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
N. Mex. Mines	2	123	125	—	8	—	—	—	—	—	—	—	—	—	—	—	—	—
New York																		
Alfred	4	—	4	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—
Brooklyn Poly.	51	676	722	5	113	2	—	—	—	—	—	—	28	295	309	14	7	—
Clarkson	11	—	11	—	3	—	—	—	—	—	—	—	—	—	—	—	—	—
City Coll. of N. Y.	—	307	307	—	13	—	—	—	—	—	—	—	—	—	—	—	—	—

New York—*Continued*																			
Columbia	422	504	920	6	135	—	—	—	—	—	—	—	25	—	25	—	2	—	
Cornell	76	—	76	—	29	1	—	—	—	—	—	—	67	—	66	1	13	—	
N. Y. Univ.	—	793	781	12	144	1	—	—	—	—	—	—	—	162	162	—	7	—	
Rensselaer	91	181	272	—	55	—	—	—	—	—	—	—	22	—	22	—	4	—	
Rochester	7	13	20	—	7	—	—	—	—	—	—	—	—	—	—	—	—	—	
Syracuse	81	380	461	—	13	1	—	—	—	—	—	—	20	8	28	—	4	—	
Union Coll.	—	61	61	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	
Webb	12	—	12	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
North Carolina																			
N. C. St. Coll.	116	—	116	—	22	—	—	—	—	—	—	—	—	—	—	—	—	—	
North Dakota																			
N Dak. Univ.	3	—	3	—	—	—	—	—	—	—	—	—	1	—	1	—	1	—	
Ohio																			
Case Inst.	103	394	491	6	59	1	—	—	—	—	—	—	41	36	77	—	16	—	
Cincinnati	10	—	10	—	14	—	—	—	—	—	—	—	10	—	10	—	3	—	
Ohio St. Univ.	192	—	192	—	144	—	—	—	—	—	—	—	82	—	82	—	43	—	
Toledo	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	
Univ. Dayton	6	40	46	—	3	—	—	—	—	—	—	—	—	—	—	—	—	—	
Oklahoma																			
Oklahoma A. & M.	79	—	79	—	35	1	—	—	—	—	—	—	11	—	11	—	—	—	
Okla. Univ.	54	—	54	—	29	—	—	—	—	—	—	—	—	—	—	—	1	—	
Tulsa	28	18	46	—	20	—	—	—	—	—	—	—	—	—	—	—	—	—	
Oregon																			
Oregon State	20	—	20	—	19	—	—	—	—	—	—	—	4	—	4	—	4	—	
Pennsylvania																			
Bucknell	2	—	2	—	6	—	—	—	—	—	—	—	—	—	—	—	—	—	
Carnegie	49	111	160	—	38	—	—	—	—	—	—	—	64	—	64	—	23	—	
Drexel	—	224	224	—	44	—	—	—	—	—	—	—	—	—	—	—	—	—	
Lafayette	2	—	2	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	
Lehigh	30	18	48	—	25	—	—	—	—	—	—	—	26	—	26	—	12	—	
Pa. St. Coll.	207	—	202	5	48	—	—	—	—	—	—	—	—	—	—	—	8	—	
Pittsburgh	78	487	565	—	51	—	—	—	—	—	—	—	13	45	58	—	4	—	
Univ. Pa.	74	566	640	—	59	—	—	—	—	—	—	—	38	25	63	—	6	—	
Rhode Island																			
Brown	12	—	12	—	1	—	—	—	—	—	—	—	4	—	4	—	—	—	
R. I. Univ.	7	1	8	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
South Carolina																			
Clemson	16	—	16	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	
South Dakota																			
S. Dak. Mines	6	—	6	—	3	—	—	—	—	—	—	—	—	—	—	—	—	—	
S. Dak. St. Coll.	1	—	1	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	
Tennessee																			
Tenn. Univ.	174	—	174	—	33	—	—	—	—	—	—	—	15	—	15	—	1	—	
Vanderbilt	4	—	4	—	3	—	—	—	—	—	—	—	—	—	—	—	—	—	

Total Graduate Engineering Enrollment, by School, October 6, 1952—*Continued*

Institutions	Number Enrolled in Work for the Master's Degree				No. of Master's Degrees Conferred in Eng'g 1951–52		Number Enrolled in Work for Other Post-Graduate Pre-Doctoral Degrees[1]				No. of Post-Grad. Degrees[1] Conferred in Eng'g 1951–52		Number Enrolled in Work for the Doctor's Degree				No. of Doctor's Degrees Conferred in Eng'g 1951–52	
	Day Students Full Time and Part Time	Evening and Special Students	Total				Day Students Full Time and Part Time	Evening and Special Students	Total				Day Students Full Time and Part Time	Evening and Special Students	Total			
			Men	Wo.	Men	Wo.			Men	Wo.	Men	Wo.			Men	Wo.	Men	Wo.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
Texas																		
A. & M. Coll. Tex.	54	—	54	—	39	—	—	—	—	—	—	—	14	—	14	—	4	—
Rice	16	—	16	—	10	—	—	—	—	—	—	—	1	—	1	—	—	—
Southern Meth.	2	256	258	—	6	—	—	—	—	—	—	—	—	—	—	—	—	—
Tex. Coll. A. & I.	2	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Tex. Tech. Coll.	7	—	7	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—
Tex. Univ.	103	—	103	—	35	—	—	—	—	—	—	—	44	—	43	1	12	—
Univ. Houston	192	—	189	3	7	—	—	—	—	—	—	—	—	—	—	—	—	—
Utah																		
Utah Ag. Coll.	11	—	11	—	3	—	—	—	—	—	—	—	—	—	—	—	1	—
Utah Univ.	28	20	48	—	6	—	—	—	—	—	2	—	10	—	10	—	—	—
Virginia																		
Va. Poly.	53	—	53	—	38	—	—	—	—	—	—	—	5	—	5	—	3	—
Va. Univ.	13	337	350	—	18	—	—	—	—	—	—	—	—	—	—	—	—	—
Washington																		
Wash St. Coll.	19	—	19	—	6	1	—	—	—	—	—	—	—	—	—	—	—	—
Wash. Univ.	127	88	214	1	62	—	—	—	—	—	3	—	8	—	8	—	4	—
West Virginia																		
W. Va. Univ.	26	4	29	1	14	—	—	—	—	—	—	—	10	—	10	—	—	—
Wisconsin																		
Univ. Wisconsin	114	138	252	—	40	—	—	—	—	—	—	—	63	—	63	—	28	1
Wyoming																		
Univ. Wyoming	12	—	12	—	7	—	—	—	—	—	—	—	—	—	—	—	—	—
District of Columbia																		
Catholic Univ.	—	72	72	—	15	—	—	—	—	—	—	—	—	3	3	—	—	—
Total ECPD Schools	7,183	9,992	17,104	71	3,989	16	239	4	243	—	126	1	2,261	669	2,906	24	584	2

[1] Other engineering degrees requiring work beyond the Master's degree, but less than the requirements for a Doctor's degree.

SECTIONS OF THE ASEE *

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Univ. of Vt.
Norwich
Dartmouth
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  Harvard
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  Mass. Inst. of Tech.
  Wentworth Tech. Inst.
  Franklin Tech. Inst.
  Northeastern
Worcester Poly. Inst.
Univ. of Conn.
Brown
Univ. of Mass.
Yale
Univ. of R. I.
U. S. Coast Guard Acad.
Bridgeport Engrg. Inst.

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New York and Vicinity:
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  N. Y. Univ.
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  Manhattan
  Academy of Aero.
  RCA Institutes
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  Brooklyn Poly. Inst.
  Pratt Institute
Newark College of Engrg.
Rutgers
Princeton
Lafayette
Lehigh
Philadelphia and Vicinity:
  Drexel Inst. of Tech.
  Univ. of Pa.
Villanova
Swarthmore
Univ. of Dela.

Capitol Section

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Univ. of Md.
Washington and Vicinity:
  Catholic
  Howard
  George Washington

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Rensselaer Poly. Inst.
Union
Syracuse
Cornell
Univ. of Rochester
Alfred
Univ. of Buffalo

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  Chrysler Inst. of Engrg.
Wayne
Univ. of Mich.
Mich. State College

Ohio Section

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Sinclair
Ohio Northern
Cincinnati and Vicinity:
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  Ohio Mech. Inst.
Ohio State Univ.
Case Inst. of Tech.
Fenn
Univ. of Akron

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Pittsburgh and Vicinity:
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  Spring Garden Institute
  Univ. of Pittsburgh
  Westinghouse Tech. Night School
West Virginia
Pa. State College
Bucknell

Southeastern Section

Univ. of Louisville
Univ. of Ky.
Va. Military Inst.
Univ. of Miss.
Univ. of Tenn.
Va. Poly. Inst.
Univ. of Va.
Duke
N. C. State College
Clemson
Univ. of S. C.
The Citadel
Ga. Inst. of Tech.
Univ. of Fla.
Ala. Poly. Inst.
Tulane
Univ. of Ala.
Louisiana State Univ.
La. Poly. Institute
Southwestern La. Inst.
Miss. State College
Vanderbilt

Missouri Section

St. Louis and Vicinity:
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  St. Louis Univ.
Univ. of Mo.
Mo. School of Mines
Univ. of Ark.
Ark. Poly. Inst.

* See "What Do You Know About Your Section?" by B. J. Robertson, Jnl. of Engrg. Ed., Feb., 1948.

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Illinois Inst. of Tech.
Univ. of Notre Dame
Purdue
Aero. Univ.
Rose Poly Inst.
Bradley

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Marquette
Univ. of Wis.
State Univ. of Iowa
Iowa State College
Univ. of Minn.
Univ. of N. D.
N. D. Agric. College
S. D. State College
S. D. School of Mines
Milwaukee School of Engrg.

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Univ. of Neb.
Kansas State College
Kansas State Teachers College
Univ. of Kansas

Southwestern Section

Okla. A. & M. College
State Univ. of Okla.
Univ. of Tulsa
Southern Methodist
A. & M. College of Texas
Rice Inst.
Univ. of Texas
Texas College of A. & I.
N. M. College of A. & M.
Univ. of N. M.
Texas Tech. College
Prairie View A. & M.

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Colo. A. & M. College
Univ. of Colo.
Colo. School of Mines
Univ. of Denver
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Ore. State College
Univ. of Wash.
State College of Wash.
Univ. of Idaho
Mont. School of Mines
Mont. State College

Pacific Southwest Section

Univ. of Ariz.
Calif. Inst. of Tech.
Los Angeles and Vicinity:
  Univ. of Southern Calif.
  Univ. of Calif.
  Cal-Aero Tech. Inst.
  Northrop Aero. Inst.
San Francisco Bay and Vicinity:
  Univ. of Santa Clara
  San Jose State College
  Univ. of Calif.
  U. S. Naval P. G. School
  Stanford University
University of Nevada

Unassigned

Univ. of Toronto
Ecole Poly.
Queens
McGill
Univ. of Alaska
Univ. of Hawaii
Univ. of Puerto Rico

ORGANIZATION OF THE SOCIETY

The Society for the Promotion of Engineering Education was the outgrowth of the meetings of Division E of the World's Engineering Congress held in Chicago from July 21 to August 15, 1893, in connection with the World's Columbian Exposition.

In June, 1946, the name of the Society was changed to The American Society for Engineering Education.

The purpose of the Society is the advancement of education in all its functions which pertain to engineering and allied branches of science and technology, including the processes of teaching and learning, research, extension services, and public relations. The Society shall serve its members as a common agency of stimulation and guidance in: (*a*) the formulation of the general goals and responsibilities of engineering education for the service of individuals and the advancement of general welfare; (*b*) the adjustment of curricula and educational processes to changing conditions; (*c*) the development of effective teachers and administrators; (*d*) the improvement of instructional materials and methods, of personnel practices, and of administrative usages; (*e*) the enhancement of professional ideals and standards; (*f*) the fostering of research as a function collateral to teaching; (*g*) the coordination of institutional aims and programs, both among schools and colleges and in their joint relations with professional, educational, and public bodies; and (*h*) the cultivation of a fraternal spirit among teachers, administrators, investigators, practitioners, and industrialists.

The Society is an organization of individual and institutional members which operates in two coordinate areas of activity, corresponding to the respective interests of these groups. The interests of the individual members are coordinated under a General Council, and the activities of its institutional members through the Engineering College Administrative Council and the Engineering College Research Council. The Executive Board is the administrative body responsible for coordinating the activities of the entire Society.

The ASEE has twenty-one Divisions and a number of Committees which represent various professional branches of science, engineering, and related fields. The Divisions and Committees arrange the technical program of the annual meeting and are responsible for much of the technical work of the Society. A number of studies of far-reaching importance to engineering colleges and the educational profession have been conducted through Division and Committee activities.

There are sixteen geographical Sections which hold regional meetings. The programs of these meetings are devoted to various timely subjects dealing with engineering education, research, administration, and professional aspects of engineering.

Local branches of the Society have been formed in a number of engineering colleges in order to further the objectives of engineering education within the colleges.

The Engineering College Administrative Council serves to foster cooperation among engineering colleges and to relate the colleges to the public welfare in the interests of the engineering profession, industry, and the public at large. It serves as an instrument of inquiry into problems which contribute to the effective administration of engineering colleges. It cooperates with agencies of the government, engineering societies, and other organizations to further the interests of engineering education.

The Engineering College Research Council assists in developing research facilities in engineering colleges and serves as an organization to promote and coordinate scientific and industrial research. The Council cooperates with governmental agencies and industrial organizations in the formulation of research programs. Through these activities the Council contributes to the improvement of advanced study in engineering colleges.

The Journal of Engineering Education, published monthly during the academic year, is the formal publication of the ASEE. It contains papers, reports and discussions pertinent to the profession. This Journal is distributed free to the members. A bound volume of the Journal constitutes the annual Proceedings of the Society.

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Date .....

I desire to become a member of the American Society for Engineering Education and hereby agree to conform to the requirements of membership, if elected, and submit the following statement of qualifications:

Name .....
Print last name First Middle

Mailing address .....

City and State .....

Full title of professional position .....
Title Department

Institution .....

Degrees and names of institutions granting .....

Sponsors .....

.....

To be signed by two sponsors, members of A.S.E.E., and returned to
A. B. Bronwell, Secretary, A.S.E.E., Northwestern University,
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Upper New York—G. K. PALSGROVE (1954), Rensselaer Polytechnic Institute, Troy, N. Y.

* Members of Council retire ten days after the annual meeting held in the year following their name.

ENGINEERING COLLEGE ADMINISTRATIVE COUNCIL

OFFICERS AND COMMITTEES

1952–53

J. H. Lampe, **Vice President, ASEE and Chairman of ECAC,** North Carolina State College.
W. L. Everitt, **Secretary,** University of Illinois.

Executive Committee: W. T. Alexander, T. H. Evans, G. W. Gleeson, R. M. Green, W. N. Jones.

International Relations: S. S. Steinberg, *Chairman*, H. O. Croft, F. M. Dawson, L. E. Grinter, H. L. Hazen, L. J. Lassalle, J. S. Thompson, R. E. Vivian, W. R. Woolrich.

Manpower Committee: D. S. Bridgman, *Chairman*, O. W. Eshbach, K. P. Hanson, S. C. Hollister, W. R. Horsley, L. H. Johnson, A. A. Soderquist.

Military Affairs Committee: William Allan, *Chairman*, J. H. Davis, E. E. Dreese, P. E. Hemke, S. C. Hollister, J. H. Lampe, E. B. Norris, M. H. Trytten, H. E. Wessman, W. C. White, W. R. Woolrich.

Selection and Guidance Committee: N. W. Dougherty, *Chairman*, D. S. Bridgman, J. F. Calvert, H. Flinsch, N. A. Parker, R. H. Roy, E. M. Schoenborn.

Committee on Secondary Schools: S. H. Pierce, *Chairman*, C. G. Brennecke, H. P. Burden, R. H. Carlton, G. A. Hawkins, P. E. Hemke, Phillip Johnson, R. D. Landon, Harold Metcalf, C. V. Newsom, R. C. Potter, J. F. Downie Smith, E. R. Wilcox.

ENGINEERING COLLEGE RESEARCH COUNCIL

OFFICERS AND COMMITTEES

1952–53

E. A. Walker, **Vice President, ASEE and Chairman of ECRC,** Pennsylvania State College (1954).
M. P. O'Brien, **Senior Vice Chairman,** University of California (1953).
K. F. Wendt, **Junior Vice Chairman,** University of Wisconsin (1954).
V. E. Neilly, **Secretary,** Pennsylvania State College.

Executive Committee: E. A. Walker, Pennsylvania State College (1954), J. H. Hamilton, University of Utah (1952), T. L. Joseph, University of Minnesota (1952), R. A. Morgen, National Science Foundation (1953), T. L. Joseph, University of Minnesota (1953), J. H. Hamilton, University of Utah (1954), A. A. Jakkula, Texas A. & M. College (1954), F. C. Lindvall, California Institute of Technology (1955), R. J. Woodrow, Princeton University (1955).

Committee on Contract Relations with the Federal Government: R. J. Woodrow, *Chairman*, W. R. Burford, A. P. Colburn, T. E. Davis, G. A. Green, W. T. Middlebrook, G. A. Rosselot, N. McL. Sage, H. A. Schade, R. B. Stewart, C. W. Williams. Ex-officio: E. A. Walker.

Committee on Relations with Industrial Research Agencies: H. K. Work, *Chairman*, S. T. Carpenter, H. O. Croft, E. W. Engstrom, G. A. Hawkins, J. H. Perrine, H. A. Schade, N. A. Shepard, H. N. Stephens, Howard Vesper, K. F. Wendt.

Nominating Committee: L. J. Lassalle, *Chairman* (1953), W. L. Everitt (1954), H. K. Work (1955).

Program Committee: R. A. Morgen, *Chairman*, A. A. Jakkula, S. S. Steinberg, K. F. Wendt.

Advisory Committee on Basic Engineering Research: E. A. Walker, *Chairman*, W. L. Everitt, Thorndike Saville, T. K. Sherwood, K. F. Wendt.

Officers retire after the Annual Meeting in the year indicated in parentheses following their name.

ASEE COMMITTEES, 1952–53

Associate Institutional Membership: J. C. McKeon, *Chairman*, Westinghouse Electric Corp., East Pittsburgh, Pa., H. K. Breckenridge, C. E. Davies, L. J. Fletcher, C. J. Freund, Keith Glennan, E. P. Hamilton, S. C. Hollister, W. N. Jones. Ex-officio: W. R. Woolrich, A. B. Bronwell.

Atomic Energy Education: H. H. Armsby, *Chairman*, U. S. Office of Education, Washington, D. C., For three years: L. M. K. Boelter, G. H. Hawkins; for two years: H. B. Hansteen, H. E. Wessman; for one year: H. H. Armsby, R. C. Ernst. Secretary: A. F. Thompson, AEC.

Constitution and By-Laws: H. H. Armsby, *Chairman*, U. S. Office of Education, Washington, D. C., L. A. Bingham, E. C. Easton, C. J. Freund, E. K. Kraybill, G. A. Marston, L. E. Seeley, L. F. Smith.

Engineering Economy: H. S. Osborne, *Chairman*, American Telephone & Telegraph Co., New York, N. Y., J. M. Apple, E. D. Ayres, J. C. Gebhard, E. M. Griswold, A. R. Gruehr, A. Lesser, J. F. Manildi, R. W. McFall, W. D. McIlvaine, S. J. Montgomery, W. R. Spriegel, H. G. Thuesen, J. E. Vivian.

Engineering School Libraries: George Bonn, *Chairman*, The Rice Institute, Houston, Texas, J. E. Allerding, C. W. Bennett, W. S. Budington, E. A. Chapman, W. R. Harvey, Wm. Hyde, P. Leslie, C. Penrose, M. Ritchie, H. E. Sauter, V. D. Tate, I. A. Tumbleson.

Ethical Standards, Promotion of: C. J. Freund, *Chairman*, University of Detroit, Detroit, Mich., W. W. Burton, N. A. Christensen, N. W. Dougherty, E. F. Obert, R. L. Peurifoy, W. M. Ryan, A. K. Schneider.

Evaluation of Engineering Education: L. E. Grinter, *Chairman*, University of Florida, Gainesville, Fla., H. H. Armsby, L. M. K. Boelter, A. P. Colburn, C. S. Crouse, J. P. Den Hartog, N. W. Dougherty, T. H. Evans, W. L. Everitt, R. C. Ernst, M. G. Fontana, D. F. Gunder, J. F. Gregg, G. A. Hawkins, P. E. Hemke, S. C. Hollister, J. A. Hrones, L. H. Johnson, J. Marin, G. Murphy, M. P. O'Brien, R. L. Pigford, D. H. Pletta, R. S. Poor, J. H. Rushton, H. Rouse, T. Saville, H. H. Skilling, A. F. Spilhaus, R. L. Sweigert, R. B. Teare, E. A. Walker, E. Weber, H. E. Wessman, C. L. Wilson, A. Wolman, W. R. Woolrich, D. Young, A. B. Bronwell.

George Westinghouse Award: F. B. Seely, *Chairman*, University of Illinois, Urbana, Ill.; (1956) Fred Pumphrey, B. G. Elliott; (1955) G. W. Gleeson, H. Rouse; (1954) H. P. Hammond, F. B. Seely; (1953), N. A. Christensen, R. E. Vivian; H. N. Muller, ex-officio.

James H. McGraw Award: H. P. Adams, *Chairman*, Oklahoma A. & M. College, Stillwater, Okla.; (1954) F. E. Almstead, Maurice Graney, Eugene Rietzke; (1953) M. Ellingson, B. K. Thorogood, A. L. Townsend. Ex-officio: E. Booher, L. F. Smith, W. R. Woolrich.

Lamme Award: F. E. Terman, *Chairman*, Stanford University, Stanford, Calif.; (1956) George Granger Brown, Jess H. Davis, J. C. Warner; (1955) J. C. McKeon, R. L. Sweigert, F. E. Terman; (1954) M. M. Boring, M. P. O'Brien, B. R. Teare; (1953) N. W. Dougherty, W. K. Lewis, K. F. Wendt.

Financial Policy: F. M. Dawson, *Chairman*, State University of Iowa, Iowa City, Iowa, S. C. Hollister, Thorndike Saville, C. L. Skelley.

Membership: W. R. Woolrich, *Chairman*, University of Texas, Austin, Texas. *Institutional Chairmen:* G. H. Dunstan, W. D. McIlvaine, W. S. Wilson, M. L. Thornburg, A. S. Turner, G. F. Branigan, E. D. Howe, D. L. Trautman, A. Hansen, C. O. Terwilliger, F. Thomas, C. E. Knott, R. J. Smith, J. N. Goodier, W. C. DuVall, C. M. Knudsen, T. H. Evans, W. M. Richtmann, H. J. Reich, F. L. Castleman, L. W. Gleekman, T. J. MacKavanaugh, M. A. Mason, L. K. Downing, F. H. Pumphrey, C. L. Emerson, J. Hugo Johnson, E. R. Whitehead, F. W. Trezise, R. A. Kliphardt, R. E. Gibbs, S. H. Pierce, D. S. Clark, H. E. Ellithorn, H. A. Moench, F. Kerekes, C. J. Posey, T. D. Carr, C. S. Crouse, M. G. Northrup, L. J. Lassalle, G. L. Corrigan, G. G. Hughes, L. H. Johnson, A. S. Campbell, L. M. Kells, A. Wolman, W. J. Huff, G. A. Marston, W. T. Alexander, G. M. Fair, R. B. Finch, W. E. Farnham, T. H. Morgan, B. K. Thorogood, M. N. Arlin, E. Boyce, W. P. Godfrey, A. R. Carr, J. M. Apple, G. P. Brewington, G. W. Swenson, L. L. Henry, C. A. Brown, E. N. Kemler, H. Flinsch, H. O. Croft, T. W. Stallworth, D. S. Eppelsheimer, J. B. Macelwane, L. E. Stout, E. W. Schilling, J. R. Van Pelt, R. M. Green, L. E. Seeley,

S. G. Palmer, S. R. Stearns, R. H. Baker, J. A. Bradley, J. L. Potter, K. H. Condit. M. E. Farris, R. M. Campbell, W. G. Camp, M. A. Thomas, Ernst Weber, N. S. Hibshman, F. H. Thomas, J. F. McManus, William Allan, J. R. Ragazzini, E. S. Burdell, H. Torgesen, L. L. Merrill, L. D. Conta, H. W. Bibber, R. A. Galbraith, G. K. Palsgrove, J. W. Green, E. K. Kraybill, R. E. Fadum, R. M. Dolve, E. L. Lium, R. D. Landon, E. H. Gaylord, H. K. Justice, G. L. Tuve, J. Arendt, G. M. L. Sommerman, R. S. Paffenbarger, J. H. Belknap, J. H. Parr, J. B. Brandeberry, E. F. Dawson, M. R. Lohman, R. L. Langenheim, W. F. Engesser, J. J. Karakash, R. G. Crosen, B. H. Bueffel, H. R. Bintzer, C. C. Chamber, J. W. Graham, C. H. Ebert, K. L. Holderman, J. D. McCrum, J. S. Morehouse, T. S. Crawford, J. H. Marchant, L. S. LeTellier, J. H. Sams, R. L. Sumwalt, H. M. Crothers, L. R. Palmerton, R. M. Boarts, F. J. Lewis, R. S. Poor, J. A. Focht, H. C. Dillingham, S. Thompson, G. S. Bonn, M. L. Ray, D. E. Holcomb, J. E. Christiansen, A. L. Taylor, A. F. Tuthill, D. L. Snader, J. B. Jones, C. Henderson, R. J. Trinkle, R. D. Sloan, F. H. Rhodes, C. H. Cather, K. F. Wendt, W. D. Bliss, H. Gaudefroy, K. F. Tupper.

Program: W. R. Woolrich, *Chairman*, University of Texas, Austin, Texas, Arthur S. Adams, H. T. Heald, J. R. Killian.

Public Relations: L. A. Rose, *Chairman*, University of Illinois, Urbana, Ill., R. G. Fiedler, J. I. Mattill, D. W. Miller, Chas. Moravec, R. W. Schmelzer, J. G. H. Thompson, Ed. Whittlesey.

Publication: A. B. Bronwell, *Chairman*, Northwestern University, Evanston, Ill., S. C. Hollister, C. L. Skelley, James S. Thompson, C. E. Watson, W. R. Woolrich.

Recognition and Incentives for Good Teaching: E. R. Stapley, *Chairman*, Oklahoma A. & M. College, Stillwater, Okla., Ralph Barnes, H. W. Case, G. A. Hawkins, P. E. Hemke, Elmer Hutchisson, L. H. Johnson, P. Nudd, H. E. Wessman.

Relations with Federal Government (Coordinating Committee): Jess Davis, *Chairman*, Stevens Institute of Technology, Hoboken, N. J., Wm. Allan, H. H. Armsby, D. S. Bridgman, J. H. Lampe, Thorndike Saville, L. F. Smith, S. S. Steinberg, E. A. Walker, R. J. Woodrow. Ex-officio: W. R. Woolrich.

Sections and Branches: M. M. Boring, *Chairman*, General Electric Company, Schenectady, N. Y., Wm. Allan, H. H. Armsby, W. P. Godfrey, D. M. Griffith, L. D. Jones, E. J. Lindahl, J. R. Lorah, C. A. Mockmore, E. F. Obert, G. K. Palsgrove, F. H. Pumphrey, N. F. Rode, B. L. Wellman, K. F. Wendt, H. H. Wheaton, D. G. Wilson.

Society Functions: B. R. Teare, *Chairman*, Carnegie Institute of Technology, Pittsburgh, Pa., H. H. Armsby, H. W. Barlow, S. C. Hollister, K. B. McEachron, Jr., D. H. Pletta, E. A. Walker.

Teaching Aids Committee: C. W. Muhlenbruch, *Chairman*, Northwestern University, Evanston, Ill., F. D. Carvin, J. H. Dawson, J. L. Hutchins, R. J. Jeffries, W. A. Nielsen.

Textile Engineering: G. N. Reed, *Chairman*, Lowell Textile Institute, Lowell, Mass., L. B. Coombs, W. D. Fales, R. B. Finch, J. E. Foster, L. H. Hance, B. W. Hayward, D. E. Holcomb, W. C. Knight, J. W. McCarty.

Young Engineering Teachers: Roger W. Sampson, *Chairman*, University of Florida, Gainesville, Fla.; *Vice Chairman (Sectional)*, M. E. Van Valkenburg; *Vice Chairman (Local)*, P. Kyburz; *Sectional Sub-Chairmen:* New England—Harold Ries; Upper New York—Joseph Salerno; Middle Atlantic—F. L. Schwartz; National Capital Area—M. S. Ojalvo; Allegheny—D. Van Meter; Ohio—R. T. Howe; Michigan—M. Ducody; Illinois-Indiana—C. E. Work; North Midwest—S. S. Johnson; Missouri—W. M. Sangster; Kansas-Nebraska—E. B. Meier, Southeastern—H. A. Owen, Jr., Merl Baker; Southwestern—R. D. Slonneger; Pacific Southwest—C. L. Sonneschein; Rocky Mountain—R. E. Leffel; Pacific Northwest—S. A. Duran, T. M. Stout. *Advisors:* D. Trautman, L. W. Gleekman.

Representatives of the Society on Various Committees, Boards, and Commissions:

American Association for the Advancement of Science:

Representatives to Council: I. P. Orens, W. R. Woolrich.

Cooperative Committee on Teaching of Science and Mathematics: M. O. Schmidt, C. E. Watson.

American Council on Education: H. T. Heald, S. C. Hollister (1955); H. S. Rogers, Thorndike Saville (1954); A. B. Bronwell, F. L. Hovde (1953).

American Society of Civil Engineers—Joint Committee on Advancement of Sanitary Engineering: Rolf Eliassen, J. C. Dietz, G. H. Dunstan, J. E. Kiker, Jr.

American Standards Association:

Y1—Abbreviations: H. C. T. Eggers, H. Porsch.

Y10—Symbols and Abbreviations: W. A. Lewis, *Chairman*, T. C. Hanson, P. J. Kiefer, W. B. Plank, M. C. Stuart, C. C. Whipple.

Sub-Committee Z10.4–1943—Letter Symbols for Heat and Thermodynamics: B. E. Short, H. L. Solberg, M. C. Stuart.

Y14—Drawings and Drafting Room Practice: H. C. Spencer, *Chairman*, F. G. Higbee, R. P. Hoelscher, W. J. Luzadder, R. S. Paffenbarger, C. L. Svenson, C. J. Vierck.

Y15—Graphic Presentation: R. S. Paffenbarger, *Chairman*, D. P. Adams, A. S. Levens, R. O. Loving.

Y32—Graphical Symbols and Drawings: I. L. Hill, *Chairman*, J. G. McGuire, R. T. Northrup.

A62—Coordination of Dimensions of Building Materials and Equipment: R. A. Caughey.

C61—Electric and Magnetic Magnitudes and Units: Harold Pender, C. V. O. Terwilliger, C. F. Rehberg.

Charles A. Coffin Fellowships and Research Committee: W. R. Woolrich.

Council: N. W. Dougherty, *Chairman*.

Educational Testing Service—Advisory H. R. Beatty, J. F. Calvert, W. R. Woolrich, ex-officio.

Engineers' Council for Professional Development: H. L. Hazen (Oct. 1955); H. T. Heald (Oct. 1954); T. S. Saville (Oct. 1953).

Engineers Joint Council:

Engineering Manpower Commission: H. H. Armsby, D. S. Bridgman, S. C. Hollister (William Allan and M. M. Boring, alternates).

General Survey Committee: M. M. Boring.

International Relations Committee: L. J. Lassalle, S. S. Steinberg.

Unity in the Engineering Profession Committee: Thorndike Saville.

National Bureau of Engineering Registration: C. L. Eckel.

National Research Council: G. A. Rosselot.

National Science Foundation—Committee on International Exchange of Students: S. S. Steinberg.

National Science Teachers Association—Future Scientists and Engineers of America: H. R. Beatty.

DIVISIONS, 1952–53

Aeronautical: K. E. Smith, *Chairman*, University of Detroit; A. J. Fairbanks, *Vice Chairman;* L. Z. Seltzer, *Secretary;* H. W. Barlow, *Member of Council*, 1953.

Agricultural: O. C. French, *Chairman*, Cornell University; R. H. Driftmier, *Vice Chairman*, F. B. Lanahan, *Secretary;* O. C. French, *Member of Council*, 1954.

Architectural: P. E. Soneson, *Chairman*, Purdue University; J. E. Varga, *Vice Chairman;* W. W. Dornberger, *Member of Council*, 1954.

Chemical: N. H. Ceaglske, *Chairman*, University of Minnesota; R. K. Toner, *Vice Chairman;* R. W. Moulton, *Secretary;* A. H. Cooper, *Editor;* R. M. Boarts, *Member of Council*, 1953.

Civil Engineering: F. W. Stubbs, Jr., *Chairman*, Purdue University; A. J. McNair, *Vice Chairman;* W. J. Eney, *Secretary;* M. B. Scott, *Editor, CE Bulletin; Directors:* C. L. Barker, J. W. Hubler, R. L. Peurifoy; E. H. Gaylord, *Member of Council*, 1954.

Cooperative Engineering Education: H. C. Messinger, *Chairman*, Univ. of Cincinnati; M. Robinson, *Vice Chairman;* W. Thomas, *Secretary;* D. C. Hunt, *Member of Council*, 1953.

Educational Methods: A. P. Colburn, *Chairman*, University of Delaware; R. L. Sweigert, *Vice Chairman;* E. Kraybill, *Secretary;* L. M. K. Boelter, *Member at Large;* H. Beatty, *Member of Council*, 1954.

Electrical: H. E. Hartig, *Chairman*, Univ. of Minnesota; L. V. Bewley, *Vice Chairman;* J. N. Thurston, *Secretary;* T. H. Morgan, *Member of Council*, 1953.

Engineering Drawing: J. J. Gerardi, *Chairman*, Univ. of Detroit; R. T. Northrup, *Vice Chairman;* J. G. McGuire, *Secretary; Executive Committee:* R. P. Hoelscher, C. Springer, Wm. Street, C. E. Rowe, H. E. Grant, J. S. Rising; W. J. Luzadder, *Editor*, J. M. Russ, *Editor, T. Square;* E. M. Griswold, *Circulation Manager;*

R. S. Paffenbarger, *Member of Council,* 1954.

English: A. M. Fountain, *Chairman,* North Carolina State College; C. R. Davis, *Vice Chairman,* W. M. Keck, *Secretary;* C. A. Brown, *Member of Council,* 1953.

Evening Engineering Education: R. W. Van Houten, *Chairman,* Newark College of Engineering; W. D. McIlvaine, Jr., *Vice Chairman;* C. E. Schaffner, *Secretary;* S. E. Winston, *Member of Council,* 1953.

Graduate Studies: N. A. Christensen, *Chairman,* Cornell University; H. L. Hazen, *Vice Chairman;* R. G. Folsom, *Secretary; Executive Committee:* G. B. Hoadley, H. E. Wessman, D. F. Peterson, J. H. Rushton, E. M. Williams, C. O. Harris; E. Weber, *Member of Council,* 1954.

Humanistic-Social Division: D. G. Stillman, *Chairman,* Clarkson College; S. P. Olmsted, *Vice Chairman;* S. Chapman, *Member of Council,* 1953.

Industrial Engineering: W. G. Ireson, *Chairman,* Stanford University; F. F. Groseclose, *Vice Chairman;* B. H. Norem, *Secretary;* B. H. Norem, *Editor;* J. M. Apple, *Member of Council,* 1954.

Mathematics: C. V. Newsom, *Chairman,* State Education Dept., Albany, N. Y.; J. H. Zant, *Secretary;* J. H. Zant, *Editor; Executive Committee:* H. M. Gehman, W. H. Krathwohl, C. R. Wylie; F. H. Miller, *Member of Council,* 1953.

Mechanical Engineering: E. L. Midgette, *Chairman,* Brooklyn Polytechnic Institute; E. E. Ambrosius, *Vice Chairman;* I. W. Smith, *Secretary;* K. P. Hanson, *Editor, Heat Power;* L. F. Kreisle, *Editor, Machine Design and Manufacturing;* H. Kuenzel, *Member of Council,* 1954.

Mechanics: D. H. Pletta, *Chairman,* Virginia Polytechnic Institute; G. Murphy, *Editor; Executive Committee:* W. B. Stiles, H. R. Lissner, W. M. Lansford, R. G. Sturm, A. L. Miller, G. Murphy, J. Marin, F. L. Singer, D. H. Pletta; C. O. Harris, *Member of Council,* 1953.

Mineral Education Engineering: J. R. Cudworth, *Chairman,* University of Alabama, W. J. Rundle, *Vice Chairman;* Wm. Chedsey, *Secretary;* C. Wilson, *Member of Council,* 1954.

Physics: G. P. Brewington, *Chairman,* Lawrence Institute of Technology; R. Seeger, *Vice Chairman;* George Burnham, *Secretary;* E. Hutchisson, *Member of Council,* 1953.

Relations with Industry: G. D. Lobingier, *Chairman,* Westinghouse Electric Corp., East Pittsburgh, Penna.; J. A. Gammell, *Vice Chairman,* G. K. Dreher, *Secretary;* K. B. McEachron, Jr., *Member of Council,* 1953.

Technical Institute: L. F. Smith, *Chairman,* Rochester Institute of Technology; L. Rouillion, *Vice Chairman;* K. Werwath, *Secretary;* H. P. Adams, *Member of Council,* 1953.

SECTIONS, 1952–53

Allegheny: C. H. Cather, *Chairman,* University of West Virginia; I. W. Short, *Vice Chairman;* A. L. Reed, *Secretary;* D. M. Griffith, *Member of Council,* 1953.

Illinois-Indiana: H. A. Moench, *Chairman;* Rose Polytechnic Institute, R. G. Owens, *Vice Chairman;* O. M. Knudsen, *Secretary; Executive Committee:* I. P. Hooper, L. D. Groves, G. V. Muller, D. H. Dahlstrom, F. I. Fiesenheiser, M. S. Peters; E. F. Obert, *Member of Council,* 1954.

Kansas-Nebraska: M. A. Durland, *Chairman,* Kansas State College; L. O. Hanson, *Vice Chairman;* A. R. LeGault, *Secretary;* D. G. Wilson, *Member of Council,* 1953.

Michigan: C. C. Winn, *Chairman,* Detroit Institute of Technology, F. L. Schwartz, *Vice Chairman;* C. C. Sigerfoos, *Secretary; Executive Committee:* L. R. Baker, G. P. Brewington, A. L. Hellwarth; W. P. Godfrey, *Member of Council,* 1954.

Middle Atlantic: W. B. Plank, *Chairman,* Lafayette College; A. W. Luce, *Vice Chairman;* H. S. Bueche, *Secretary;* Wm. Allan, *Member of Council,* 1953.

Missouri: G. F. Branigan, *Chairman,* Univ. of Arkansas; F. H. Conrad, *Vice Chairman;* R. C. Johnson, *Secretary;* J. R. Lorah, *Member of Council,* 1953.

National Capital Area: L. K. Downing, *Chairman;* C. H. Walther, *Vice Chairman;* D. C. Jackson, Jr., *Secretary;* H. H. Armsby, *Member of Council,* 1954.

New England: E. T. Donovan, *Chairman;* Univ. of New Hampshire; E. F. Littleton, *Secretary;* B. L. Wellman, *Member of Council,* 1953.

North Midwest: S. J. Chamberlin, *Chairman,* Iowa State College; A. B. Drought, *Vice Chairman;* Wm. C. Alsmeyer, *Secretary; Executive Committee:* E. P. Wiedenhoefer, A. B. Cambel, C. O. Anderson,

W. H. Gamble, M. H. Chedrick, O. W. Potter, T. J. Higgins; K. F. Wendt, *Member of Council*, 1954.

Ohio: H. K. Justice, *Chairman*, Univ. of Cincinnati; E. O. Scott & N. D. Thomas, *Vice Chairmen;* K. F. Sibila, *Secretary;* L. D. Jones, *Member of Council*, 1953.

Pacific Northwest: J. P. Spielman, *Chairman*, Washington State College, R. K. Reynolds, *Vice Chairmen;* L. D. Luck, *Secretary;* C. A. Mockmore, *Member of Council*, 1954.

Pacific Southwest: C. E. Cherry, *Chairman*, College of Marin; C. E. Knott, *Vice Chairman;* J. B. Franzini, *Secretary;* H. H. Wheaton, *Member of Council*, 1953.

Rocky Mountain: C. A. Hutchinson, *Chairman*, Univ. of Colorado; A. Diefendorf, *Vice Chairman;* K. H. Stahl, *Secretary;* E. J. Lindahl, *Member of Council*, 1954.

Southeastern: D. V. Terrell, *Chairman;* Univ. of Kentucky; J. R. Cudworth, *Vice Chairman;* B. M. Bayer, *Secretary;* F. H. Pumphrey, *Member of Council*, 1953.

Southwestern: M. L. Ray, *Chairman*, Univ. of Houston, J. J. Heimerich, *Vice Chairman;* T. T. Castonguay, *Secretary;* N. F. Rode, *Member of Council*, 1954.

Upper New York: R. M. Campbell, *Chairman*, Alfred University; B. H. Norem, *Vice Chairman;* A. D. Taylor, *Secretary;* G. K. Palsgrove, *Member of Council*, 1954.

BRANCHES, 1952–53

Alabama (University): G. C. K. Johnson, *Chairman*, Herbert Kuenzel, *Vice Chairman*, J. A. Bennett, *Secretary-Treasurer.*

Arizona: C. H. Handforth, *Chairman*, H. A. Marcoux, *Vice Chairman*, Martin Hochdorf, *Secretary.*

Bucknell: Hugh D. Sims, *Chairman*, Robert Slonaker, *Secretary-Treasurer.*

Case: R. C. Putnam, *Chairman*, W. R. Meredith, *Vice Chairman*, D. M. Rein, *Secretary-Treasurer.*

Colorado A. & M. College: C. C. Britton, *Chairman*, H. H. Schweizer, *Vice Chairman*, H. B. Mummert, *Secretary-Treasurer.*

Colorado (University): W. F. Boore, Jr., *Chairman*, W. J. Hanna, *Secretary.*

Colorado School of Mines: G. W. LeMaire, *Chairman*, F. K. Sabott, *Vice Chairman*, M. C. Smith, *Secretary-Treasurer.*

Detroit: Guido Ferrara, *Chairman*, Louis S. Clock, *Vice Chairman*, Kenneth Smith, *Secretary.*

Florida: John E. Kiker, *Chairman*, F. H. Pumphrey, *Vice Chairman*, R. J. Cummings, *Secretary.*

Lafayette: L. J. Conover, *Chairman*, G. W. Courtney, *Vice Chairman*, T. R. Blakeslee, *Secretary.*

Maine: E. F. Thode, *Chairman*, F. J. Sullivan, *Vice Chairman*, W. W. Turner, *Secretary.*

Michigan College of M. & T.: E. P. Wiedenhoefer, *Chairman*, C. C. Aird, *Vice Chairman*, P. I. Koski, *Secretary.*

Michigan State College: R. J. Jeffries, *Chairman*, Robert L. Sweet, *Vice Chairman*, Frank C. Flory, *Secretary*, Donald A. Bergh, *Treasurer.*

Minnesota: H. D. Myers, *Chairman*, C. E. Lund, *Program Committee Chairman*, Paul Cartwright, *Secretary*, R. L. Dowdell, *Treasurer.*

Newark College of Engineering: F. N. Entwisle, *Chairman*, —— —— ——, *Secretary.*

North Carolina State College: W. F. Babcock, *Chairman*, D. S. Arnold, *Vice Chairman*, J. K. Whitfield, *Recording Secretary*, Lodwick Hartley, *Corresponding Secretary.*

Northeastern: O. F. Cushman, *Chairman*, J. J. Devine, *Secretary.*

Pennsylvania State College: V. E. Neilly, *Chairman*, J. H. Moore, *Secretary-Treasurer.*

University of Tennessee: C. A. Newton, *Chairman*, H. J. Garber, *Secretary-Treasurer.*

Texas A. & M. College: N. F. Rode, *Chairman*, B. F. K. Mullins, *Vice Chairman*, E. S. Holdredge, *Secretary.*

Tufts College: E. F. Littleton, *Chairman*, D. A. Fisher, *Secretary.*

State College of Washington: Harry Stern, *Chairman*, A. B. Caseman, *Vice Chairman*, J. H. Johnson, *Secretary-Treasurer.*

University of Washington: F. D. Robbins, *Chairman*, J. B. Morrison, *Secretary.*

TECHNICAL INSTITUTE BRANCHES, 1952–53

Milwaukee School of Engineering: Fred Kaufmann, *Chairman*, Richard Ungrodt, *Vice Chairman*, Rudolph Sundstrom, *Secretary-Treasurer.*

AWARDS

LAMME MEDAL

The Lamme Award consists of a gold medal and bronze replica bestowed annually upon a distinguished engineering educator for excellence in teaching and contributions to the art of teaching; contributions to research and technical literature; achievements which contribute to the advancement of the profession; and engineering administration. The Lamme trust fund was established in memory of Benjamin Garver Lamme.

RECIPIENTS OF LAMME MEDAL

1928—George Fillmore Swain, Professor of Civil Engineering, Harvard University.

1929—Irving Porter Church, Emeritus Professor of Applied Mechanics and Hydraulics, Cornell University.

1930—Charles Felton Scott, Professor of Electrical Engineering, Yale University.

1931—Dugald Caleb Jackson, Professor of Electric Power Production and Distribution, in charge, Dept., Electrical Engineering, Massachusetts Institute of Technology.

1932—Arthur Newell Talbot, Professor of Municipal and Sanitary Engineering, Emeritus, University of Illinois.

1933—Dexter Simpson Kimball, Professor Emeritus of Industrial Engineering, Dean, College of Engineering, Cornell University.

1934—Edward Rose Maurer, Professor of Mechanics, University of Wisconsin.

1935—William Elgin Wickenden, President, Case School of Applied Science.

1936—Herman Schneider, Dean, University of Cincinnati.

1937—Frederick Eugene Turneaure, Dean, University of Wisconsin.

1938—Robert Lemuel Sackett, Dean, Pennsylvania State College.

1939—Stephen P. Timoshenko, Professor of Theoretical and Applied Mechanics, Stanford University.

1940—Andrey A. Potter, Dean, Schools of Engineering, Purdue University.

1941—Anson Marston, Dean Emeritus of Engineering, Emeritus, Iowa State College.

1942—Roy Andrew Seaton, Dean Emeritus, Division of Engineering, Kansas State College; Director, E. S. M. W. T., U. S. Office of Education.

1943—Thomas Ewing French, Professor of Engineering Drawing, Emeritus, The Ohio State University.

1944—Hardy Cross, Professor and Chairman, Dept. of Civil Engineering, Yale University.

1945—Harry Parker Hammond, Dean Emeritus, School of Engineering, The Pennsylvania State College.

1946—Robert E. Doherty, President, Carnegie Institute of Technology.

1947—Warren K. Lewis, Professor of Chemical Engineering, Massachusetts Institute of Technology.

1948—Alexander G. Christie, Professor Emeritus of Mechanical Engineering, Johns Hopkins University.

1949—Karl Taylor Compton, President Emeritus, Chairman of Corporation, Massachusetts Institute of Technology.

1950—Fred B. Seely, Professor of Theoretical and Applied Mechanics, University of Illinois.

1951—Allan R. Cullimore, President Emeritus, Newark College of Engineering.

1952—Solomon Cady Hollister, Dean of Engineering, Cornell University.

THE GEORGE WESTINGHOUSE AWARD

The George Westinghouse Award was established by the Westinghouse Educational Foundation in 1946 as an annual Award to young engineering teachers of outstanding ability to recognize and encourage their contributions to the improvement of teaching methods for engineering students.

RECIPIENTS OF THE GEORGE WESTINGHOUSE AWARD

1946—James Norman Goodier, Professor of Mechanics, Cornell University.
1947—Benjamin R. Teare, Jr., Buhl Professor and Head, Dept. of Electrical Engineering, Carnegie Institute of Technology.
1948—Hunter Rouse, Professor and Director, Institute of Hydraulic Research, State University of Iowa.
1949—Joseph Marin, Professor of Engineering Mechanics, Pennsylvania State College.
1950—Rolf Eliassen, Professor of Sanitary Engineering, Massachusetts Institute of Technology.
1951—Glenn Murphy, Professor of Theoretical and Applied Mechanics, Iowa State College.
1952—Gordon S. Brown, Professor and Head of Electrical Engineering, Massachusetts Institute of Technology.

JAMES H. McGRAW AWARD

The James H. McGraw Award in Technical Institute Education is awarded annually for the purpose of recognizing and encouraging outstanding contributions to technical institute education. The Award consists of the sum of $500.00 and an engraved certificate provided by the McGraw-Hill Book Company in memory of James H. McGraw, Sr. Nominees are expected to have displayed unusual competence in one or more of the following activities related to technical institute education: instruction, publication, administration, and other appropriate contributions.

1950—Harry P. Hammond, Dean of Engineering, Pennsylvania State College.
1951—Robert Hoover Spahr, Administrative Chairman, General Motors Institute.
1952—Arthur Lyman Williston, Principal (retired), Wentworth Institute.

Do You Know That—

► President Woolrich represented the ASEE at a European Conference on Engineering Education held in London during the week of January 19–23. The Conference was also attended by delegates from Belgium, Denmark, France, Germany, Holland, Italy, Norway, Sweden, Switzerland, and the United Kingdom. Dean Saville and Col. L. F. Grant represented the ECPD at this conference. A report on the conference will be presented at the Annual Meeting at Gainesville. Several European representatives have expressed a desire to form a society for engineering education similar to ASEE.

► From Dr. L. E. Grinter, Chairman of the Committee on Evaluation of Engineering Education, comes the report that the Committee has held three meetings in its comprehensive investigation of the organization, curricular content, and teaching methods of engineering education. A large number of engineering colleges have appointed local committees to cooperate with the ASEE Committee in studying various phases of this program. A contribution of $3,000 has been received from the Engineering Foundation for this project and additional funds have been pledged by the Engineering Societies making up the Engineers' Council for Professional Development.

► A conference was arranged by the ECAC with administrative officials of the Mutual Security Agency (MSA) and the Technical Cooperation Administration (TCA) to discuss the government's foreign assistance programs in the fields of technological education and research. As a means of furthering this constructive relationship, both MSA and TCA have asked ASEE to appoint an Advisory Committee to assist them in future planning. Dr. Ralph Morgen, Program Director for Engineering of the National Science Foundation, is Chairman of the newly appointed Advisory Committee.

► The Report of the Committee on Improvement of Teaching has received high commendation not only from members of the Society, but also from many leading organizations and individuals outside the ASEE. Over 10,000 copies have been sent to engineering colleges for distribution to faculty members. The second printing of this report is nearly gone. Price, 15¢ per copy for less than 100 or $8.00 per hundred.

► A project of considerable significance to engineering education is the program of the Teaching Aids Committee. This Committee is reviewing Teaching Aids in the fields of Civil Engineering, Electrical Engineering, Mechanical Engineering, Mechanics, Physics, and Mathematics. Carl Muhlenbruch, Chairman, says that the bulletin listing Teaching Aids of acceptable quality for engineering instruction will be available about the time of the Annual Meeting in June.

► The ASEE has joined the Engineers' Joint Council under the Council's new plan of expansion to unify the engineering profession. Dean Saville will serve as the Society's first representative. He was elected as Vice President of EJC at the organizational meeting, January 23.

► The Paper Contest announced earlier this year for Young Engineering Teachers has received the enthusiastic approval of the younger faculty members throughout the country. The awards of $200 and $100 for the two winning papers will be presented at the Annual Banquet of the Society at Gainesville, Florida.

► Dean C. J. Freund, Chairman of the ASEE Committee on Promotion of Ethical Standards, is conducting a study to determine the extent to which ethical concepts of the profession have been assimilated into engineering education. A preliminary report will be presented at the Annual Meeting of the Society.

► Did you notice that this issue of the *Journal* contains the first advertisements of teaching positions in engineering colleges and technical institutes? This is a new service to the individual membership of the Society as well as to institutional members. It is hoped that these advertisements might serve not only to place teachers in positions commensurate with their interests and abilities, but also to entice capable scientists and engineers from industry into the teaching profession, thus reversing the recent trends.

► Dean Lampe, Vice-President of ASEE, arranged several conferences between ECAC and ROTC officials last Fall to clarify matters of ROTC policy. This resulted in an official statement of policy by the Airforce ROTC and clarification of Army policy. Dean Lampe also states that the ECAC Committee on Secondary Schools is making significant progress in bringing divergent views to bear upon the problem of High School-College articulation.

► Mr. D. Bridgman, Chairman of the ECAC Manpower Committee, will present an overall analysis of the manpower situation which will consider the effects of increased ROTC quotas, increased Selective Service calls, etc. A problem of grave concern is the prospect of vanishing graduate enrollments, resulting from the combined effects of ROTC and Selective Service.

► The ECAC Committee on International Relations will hold a conference and a dinner meeting at the Annual Meeting of the Society. Invitations are being sent to educators in all foreign lands outside the Iron Curtain.

► Vice-President Eric Walker vows that the ECRC's new Directory of Current Research will be available before the Annual Meeting in June. This year the ECRC will invite Associate Institutional Members to participate in its activities at the Annual Meeting in Gainesville.

► The ECRC Committee on Relations with the Federal Government, Dr. R. J. Woodrow, Chairman, has done yeoman service in keeping deans of engineering colleges and directors of research informed on current research policies and practices of the government.

► The Relations With Industry Division held its semi-annual meeting at Northwestern University, with an attendance of over 300 industrial representatives and educators on January 31. An outstanding program dealing with the recognition and encouragement of potential engineering talent in high schools, the better utilization of engineering manpower, personal motivations in industry, and the continued learning processes of the engineer after graduation, made this meeting an outstanding occasion.

► The Engineering Drawing Division held a highly successful Mid-Winter Meeting January 29–31 at the University of Nebraska. Papers dealt with the opportunities and responsibilities of drawing departments, manufacturing and design problems, and other subjects of interest to drawing teachers.

► The Cooperative Engineering Education Division held its Mid-Winter Meeting at Fenn College, January 22–23. Its "Work-Shop" program consisting of round-table discussions on administrative problems and operational techniques is a highly constructive feature of the Mid-Winter Meetings.

► The Industrial Engineering Division of ASEE is planning a summer school to precede the Annual Meeting at Gainesville. A stimulating and constructive program which will appeal to all industrial engineering teachers is being planned.

► Also, the General Electric Company, in cooperation with the Educational Methods Division of the Society, will again sponsor a summer school, presenting some of the material of the advanced engineering program. This summer school was highly commended by those who attended last year.

► Vice-President W. C. White has announced that preliminary returns on the Conference Programs for the Annual Meeting at the University of Florida are highly encouraging. The Divisions and Committees of the Society have selected program material and speakers which assure a vigorous and constructive approach to the many challenging problems in engineering education.

► The ECRC will have a General Session around the theme "Encouragement of Fundamental Research as an Aid to Education in Engineering," with nationally prominent speakers. . . . The other General Sessions will also be on subjects of vital interest to the membership, and will have speakers of national distinction. . . . A unique feature of the Annual Meeting will be a General Session on Monday afternoon dealing with the principal ASEE projects now in progress. This will include an open-forum discussion to bring the membership into more active participation in the constructive work of the Society. . . . The Engineering Economy Division has arranged a program containing a number of leading economists in industry on subjects of significance to all engineering educators. . . . The Mathematics Division has arranged to have Dr. Curtiss of the National Bureau of Standards, a nationally recognized authority, present several lectures on Electronic Digital Computers. . . . The Atomic Energy Committee is again holding a conference on Atomic Energy Education, a repeat on last year's highly successful conference. . . . More on the Annual Meeting program in the April issue.

► The local planning committee at the University of Florida is doing a splendid job in arranging for facilities and recreational plans for the Annual Meeting. They assure us that they have complete control of the weather in June!

► Vice-President Boring reports that most of the Section Meetings have had larger attendance than any previous meetings and that the programs have been pointed at issues of vital current interest to engineering educators. Most of the Sections have taken active steps to bring younger faculty members into participation in Society functions—a prime objective of the Society.

► A salute to the excellent work of the ASEE Divisions which publish their own quarterly or semi-annual publications—the *Civil Engineering Bulletin, Journal of Engineering Drawing, Machine Design Bulletin, Heat Power News,* and *Chemical Engineering Abstracts.* These are self-financing projects which perform a distinguished service in engineering education.

► Did you notice the new advertising in the *Journal*? Professor Watson, our new Assistant Secretary, estimates the increased revenue to exceed $3000.

► Two new active committees, not previously mentioned, which were appointed this year, are the Committee on Recognition and Incentives for Engineering Education, with Dean E. R. Stapley as Chairman, and the Committee on Improvement of Society Functions, with Dean B. R. Teare, Chairman.

► The Fall Meetings of the ECRC, ECAC, and General Council will be held in conjunction with the Annual Meeting of ECPD at the Statler Hotel, New York, October 15–17, 1953.

► Will see you at Gainesville,

ARTHUR BRONWELL,
Secretary

The Nation's Florida—Everybody's Playground

ASEE Annual Meeting, June 22-26, 1953, University of Florida, Gainesville, Florida

By HAROLD COLEE

FLORIDA *belongs to the nation . . . and to everyone in it.*

The French have a saying, "Everybody has two countries—his own and France." Its popularity as a mecca for tourists has been achieved by the psychology of that kind of thinking. France surrenders to the invasion of its cosmopolitan visitors with a fine Gallic sense of values.

Floridians, too, might well say, "Everyone is a citizen of two states—his own and Florida," . . . for Florida truly belongs to the nation, and to everybody in it. Indeed, it is fast assuming the proportions of an international resort area, welcoming in ever-increasing numbers Canadians and Latin-Americans.

Florida is a national asset—without peer.

Can you imagine America without it?

Picture, if you can, the southeast corner of the United States neatly carved off at a point somewhere north of Jacksonville, curving gently into the northern shoreline of the Gulf of Mexico, with the lush, subtropical peninsula only a misty mirage against the merging blues of the southern horizon.

No Florida? What would our nation be without it—except, possibly, a blessing to cartographers who seem reluctant to map Florida in one piece and without confusing mutilation. Florida is a *united* state, as we boasted in the war year of 1941, and we like to see it united geographically as a bountiful nature conceived and formed it. Surely, it is God's gift to the American people, and to the peoples of *all* the Americas.

Geologists are not precisely agreed on the period of Florida's existence, but we like to think of it as being blueprinted from the very beginning by the Creator; for surely, the mind of man could not conceive it, much as he seeks now to improve it. Geologists do know that Florida was here in the Pleistocene Age from the ancient rock foundation and its gentle steppes of alluvial deposits —as opposed to the theory of sands piled up on fragile coral reefs. No, Florida is the handiwork of the Great Architect, built solidly on the rock of ages to last forever, that untold future generations might, too, enjoy its myriad blessings.

Physically, some see Florida as a tapering finger curving gracefully into the tropical Gulf, pointing southward as a silent invitation to its northern friends and neighbors. Florida *is* inviting, but we in the Florida State Chamber of Commerce like to visualize it as a horn of plenty—a giant cornucopia swinging upward into the broad, open expanse of its northern borders, from which flows the rich bounty of its farms, groves, mines and forests.

Citrus Industry

Gushing forth is a veritable Niagara of golden, health-giving citrus (119 million boxes last year valued at $190 million), a torrent of rich green winter vegetables and other crops of farm and grove; a bountiful flow of forest products: pulp, paper and kraft board . . . a silver

stream of phosphate (70% of the world's total) . . . of limerock and other minerals . . . and the abundant harvest of the sea.

These products of Florida plus an expanding variety of manufactured goods, ranging from native handcraft to electronics, offer ample evidence of the state's balanced economy, of year-round employment and growing payrolls.

Productivity is high because of the healthful, energizing climate; and absenteeism due to inclement weather, dangerous driving conditions and the common cold, is almost unknown.

Florida is a working state, but its greateset claim to fame and largest source of income lies in its incomparable charm as "Vacation-land, U. S. A."

Claim to this tile is due primarily to its unique geographical position between the 31st and 24th parallels, north latitude. We are not, however, technically within the tropics, being one hundred miles north of the Tropic of Cancer. The southern tip of Florida is nearer the equator than any other portion of continental United States. Miami is 500 miles south of San Diego, California. In this insular position between the broad expanse of the Atlantic and broad reaches of the Gulf of Mexico, Florida is bathed with cool trade winds in summer and warm breezes in winter, tempering the extremes at all times.

Another Florida "believe-it-or-not" is: although an Eastern seaboard state, Florida's northern metropolis, Jacksonville, is directly beneath Cleveland and Pensacola below Chicago. A line drawn from Maine's northeast coastline would run 837 miles east of Jacksonville. All of South America lies east of Florida. Thus, Florida properly belongs in the Central Time Zone, but except for Pensacola, we set our clocks with those of the East.

South of the so-called Deep South, Florida is populated largely by Northerners and natives of other states, and the welcomed invasion of new citizens has continued for the past ten or fifteen years at the rate of a thousand a week.

Latin-American Trade and Culture

Florida, too, is near more foreign nations than any other state, and virtually is in the center of the Americas, whose peoples visit here in mounting numbers. Latin-American trade and culture has been developed to such a degree that Spanish is now being taught in the elementary schools of Dade (Miami) and Hillsborough (Tampa) counties. A $40 million Inter-American Cultural and Trade Center will soon be under construction in Miami to strengthen and encourage this good neighbor policy. As a result, the southern peninsula is acquiring a cosmopolitan air and succeeding generations will, in all probability, become bi-lingual, speaking Spanish or Portuguese as well as English.

Florida is big. The tapering formation of the peninsula deceptively belies its true expansiveness—54,262 square land miles, comparable in area to Iowa or Michigan and a trifle larger than New York State. Motorists are sometimes amazed to learn 508 miles separate Jacksonville from Key West—834 miles between Key West and Pensacola; and Pensacola is due west from Jacksonville a distance of 370 miles; and across the state from Miami to Tampa, 260 miles.

"Vacationland"

All of Florida is "vacationland," offering varied charm ranging from the quaint old-south complexion of the northwest counties to the Spanish atmosphere of Tampa and Key West, and the subtropical glamour of the famous Gold Coast. Depending upon individual preference, one will find tourist accommodations to fit everyone's vacation budget.

Florida is host to the nation, last year providing for 4,800,000 visitors and from whom was derived the immense sum of $840,000,000. Where did these people come from? Nearly half of them came from nearby Southeastern states; nearly 20 per cent from Middle Atlantic states

(New York, New Jersey, Pennsylvania); 16 per cent came from Ohio, Indiana, Illinois, Michigan and Wisconsin; and between three and four per cent each from New England, the Southwest, North Central Pacific Coast and Latin-America. Canada and other foreign nations were represented by half of one per cent. Citizens from every state in the union and possessions were registered last year in Florida hotels.

Modes of travel differed but it is estimated that nearly half of the visitors traveled by automobile. Twenty-four per cent, or 1,152,000 came by train; 19 per cent, or 912,000 by bus; and eight per cent, or 384,000 by plane.

. . . Where do these vast numbers of folks stay? . . . How are they housed? . . . fed? . . . entertained? It is a large order, but Florida is geared to it and is constantly expanding its facilities to meet the increased demand.

More than 30,000 hotels, apartment and rooming houses, motels and cottage colonies provide some 575,000 rooms for our visitors; while 13,000 restaurants can seat at one time about 600,000 persons. The daily food consumption would feed an army, and much of it is raised within the state from our own farms, groves and cattle ranges. Catering to the needs, comfort and entertainment of our guests are thousands of cooks, waitresses and other service people imbued with the traditions of southern courtesy whose welcome is always friendly and whose farewell is the invariable admonition, "Come back and see us, he-ah?"

Yes, Florida extends a warm welcome to its visitors in keeping with its climate. Typical Northerners, on their first visit, find it hard to realize that the delightfully balmy air of a warm June night can prevail such a few short air miles from freezing temperatures and knee-deep snow. They marvel at the rich green foliage, the vivid coloring of tropical flowers blooming in profusion through the midwinter months.

The clear blue of the Florida sky banked with billowing white clouds, the star-lit night and brilliant moonlight . . . are revelations in natural beauty to the new visitor. But who has not seen and enjoyed these familiar Florida scences? Despite the millions who have come here and the thousands of newcomers attracted each year, new generations will continue to come and marvel to the end of time.

Summer Vacation Spot

When it's June in January many new visitors ask, "What must it be like in July and August?" A logical process of reasoning leads to the belief that the weather must naturally become increasingly warmer through the spring and summer; but this is not true—as millions of summer vacationers have happily learned. Paradoxically, "fabulous Florida" is warm in winter, cool in summer . . . like the ancient fable of the man who blew to warm his hands and blew again to cool his soup. Florida winds do both.

Have you ever seen newsphotos of Floridians sleeping on fire escapes or in public parks to avoid the heat? Have you ever heard of sunstroke or heat prostration in Florida cities? No, never, because the Peninsula State is air-conditioned by nature; and the system never fails. Summer nights are cool following the hottest day.

Occasionally sumer heat waves from the North and West penetrate into the Florida peninsula, as do nation-deep cold fronts of winter; but when it is uncomfortably warm here, it is invariably warmer there, and when it is chilly here, it is much colder there. This statement can be verified in the weather report in your daily newspapers.

Known the world over as a delightful winter resort, Florida is becoming equally famed as a summer vacation-land with an increasing number of visitors arriving during July and August. Last year nearly 1,500,000 tourists came here in midsummer to enjoy themselves for rest, recreation and physical refreshment.

The summer season offers many more

Florida's 3,800 square miles of inland water makes an ideal playground for the small boat owner and ardent fisherman. Bass, bream and crappie fishing will reach the peak in Florida during the winter months.

attractions, much more in the way of sports and entertainment and at a considerably less cost than at the peak of the winter season. The beaches of Florida's nearly 2000 mile salt-water shoreline are at their best, crowded with carefree vacationers from sun-up until dark. Fishing is also at its peak in summer months in some 30,000 fresh water lakes and rivers, as well as for deep-sea angling and the popular surf-casting. Recreation centers, resorts and attractions are crowded with vacationers. All Florida seems to take on a carnival air in summertime as thousands of pleasure-loving Floridians join their visitors in enjoying themselves in the great out-of-doors.

Seasonal fluctuations are less noticeable in recent years, and spring and fall vacations are growing in popularity. Autumn holds special appeal for the hunter aware of the variety of game birds and other wildlife with which Florida abounds. The early flights of waterfowl and other migrant game birds provide good shooting and limit bags for visiting nimrods. Many others come to this state before the advent of wintry weather and to avoid the chill gray days of October and November. They have learned, too, that the early visitor finds a better choice of accommodations and that seasonal reservations are usually more economical.

Easter vacation periods bring an influx of families during the school holidays as a preview of summer and to break the monotony of prolonged northern winters. In fact, the Florida tourist season seems to continue uninterruptedly around the calendar. Each year the so-called winter season seems to start earlier and last longer; while summer business is beginning to show signs of extending from Spring to Fall.

Where to Go and What to Do

Whatever the season, newcomers are often perplexed as to where to go and what to do. If they have written the State Advertising Commission, the State

Chamber or local chambers of commerce for literature, they are probably overwhelmed with the multiple attractions described on the East Coast and Central Florida and in the historical Northwest. Truly, one section of the state seems to offer more attraction than another—even discounting the usual superlatives of travel folder descriptions. Much depends on your tastes.

Season visitors to the West Coast look down their noses at East Coast devotees —and vice versa. Big city fans who enjoy metropolitan attractions cannot understand people who "bury themselves" in small interior towns. South Florida regulars scoff at those who prefer North Florida areas, and so it goes ad infinitum. Personal preferences, happily, distribute the millions of visitors fairly evenly throughout the state, according to individual tastes.

The State Chamber, like a doting father with many children, has no favorites, recognizing in each section of the state certain regional advantages and few, if any, faults. However, the visitor able to do so should try to see all Florida before deciding definitely where to stay. This is especially desirable when contemplating permanent residence here.

Throughout the state, vacationers will find an unbelievable variety of interesting things to see and do. For the nature lover, Florida can offer some of the most beautiful sub-tropical scenery in the world—glistening beaches, graceful palms, gay exotic flowers, bright clear skies and sparkling waters.

From the beaches of either coast it is but a few minutes drive to the great stretches of state parks where nature, untouched, offers scenes of primitive grandeur. More than 30,000 named lakes, and streams provide unparalleled fishing and boating. No matter what season of the year, you will find a great variety of things to see and do. Sports fans will find the season full with major events: regattas, racing, rodeos, golf and tennis tournaments, swimming meets and major league baseball games. Florida's pageants and festivals are world famous, and run through the calendar in various parts of the state. Attendance at such festivities is not costly and many of them are free.

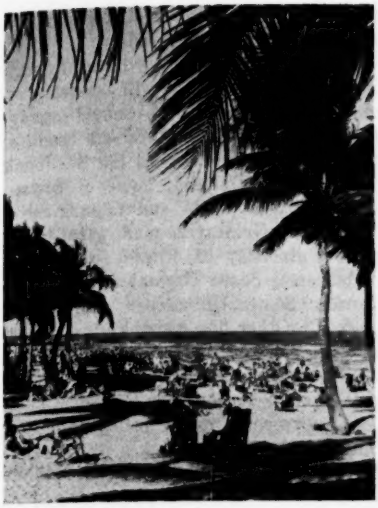
Motor Trips

A motorist approaching along the Atlantic coast will find numerous interesting spots and stops: Fernandina, site of some of Florida's most colorful history; Jacksonville, northern metropolis; St. Augustine, America's oldest city, with its ancient Spanish fort and historical building, its alligator and ostrich farms, and museums; Marineland with its trained porpoises and vast display of live marine life; Daytona Beach, where auto and motorcycle races are run on the broad smooth sands; numerous lovely tropical gardens; beautiful beach resorts, the Palm Beaches and the Gold Coast's famed Miami area cities and suburbs, offering inexhaustible sources of interest and enjoyment.

One of the most unusual motoring trips is that from Miami to Key West over 122 miles of the famed Overseas Highway. This roadway, which is actually a series of bridges from key to key, passes over more water than land on its course to Key West. There is excellent fishing along the way, and many places for pleasant stopovers while enjoying the journey. Unusual food is available in this section: turtle steaks, conch chowders, and lime pies being among the favorites of the epicure. The lower keys are steeped in legends of lost Spanish gold, and buried pirate loot. The Spanish Flotilla, the Great Treasure Fleet of the Conquistadores, had ships wrecked on the ragged reefs of these waters. Millions in gold were reputed to have been lost and the seagoing hijackers of a later period are believed to have cached much booty on lonely little keys now crossed by the unique motor seaway.

Everglades National Park

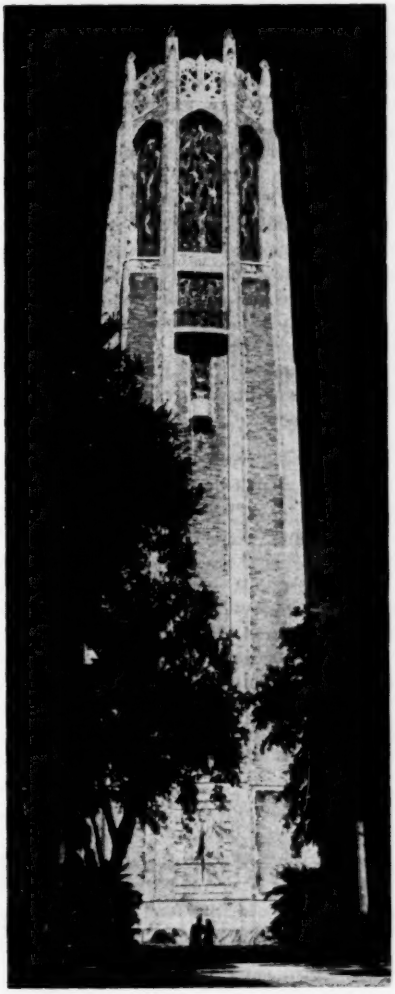
One of the most unusual attractions in America is the Everglades National Park. This vast wildlife sanctuary can be reached via U. S. Highway 1 south to



MIAMI BEACH, Fla.—Palms, sea, and sand, along with the famous Florida sun make this fabulous beach a Mecca for winter and summer visitors.

Homestead where well-marked trails lead the visitor to the numerous points where there are nature walks. In winter it is possible to observe much of the park's native wildlife—alligators, egrets, water turkeys, wood ibis, pelicans, deer and other game. The jungle-like, subtropical vegetation holds great fascination for the visitor; such trees as the gumbo-limbo, paradise tree, and strangler fig; and wild orchids and native ferns which abound in this natural setting. Audubon Wildlife tours are conducted from Miami to the park during the winter season, and bus lines include a portion of the park in special tours.

Crossing the state from Miami to the Gulf Coast along the Tamiami Trail, the traveler passes through Everglades country. On either side of the highway is a great sea of saw grass and palmetto. A short way off the highway, the interior will often reward the nature lover with a view of rare flowers and tropical birds. Arriving at Fort Myers, once the winter home of Thomas A. Edison, one finds a beautiful city celebrated also for its sports fishing. A visit to Edison Gardens is a pleasant interlude, featuring unusual



LAKE WALES, Fla.—Florida's Singing Tower is a memorial to Edward W. Bok, noted journalist and Nobel Prize winner. The area surrounding the tower is a bird sanctuary and garden. The tower's carillon of 71 bells is played for concerts during the winter season.

tropical plants collected from the faraway tropics by Mr. Edison himself.

Sarasota, winter home of the great Ringling Brothers circus, is also the site of the Ringling home and Museum of Art, the latter willed to the State of Florida by the late John Ringling. In this central Gulf section, facing each other across the bay, are two of Florida's most charming vacation cities, St. Petersburg, and Tampa. Northward from this point stretch miles of unspoiled native scenery.

The visitor will not wish to miss the central section of the peninsula. Here in the rolling hills are miles of sweet-scented citrus groves, packing houses and processing plants. Miles of rich pasture land support Florida's huge cattle industry, famous for its humped-back Brahman crossbreeds, truck farming and dairy business.

The Central Interior

In the central interior of the Ridge Section may be found delightful scenic splendor and attractions, including the Bok Tower at Lake Wales. The 71-bell carillon presents concerts through the winter season. Within the same area is a new attraction, *The Great Masterpiece,* a huge mosaic reproduction of Leonardo da Vinci's magnificient painting, *The Last Supper.* Cypress Gardens at Winter Haven puts on breath-taking water ski shows daily in a beautiful setting of tropical shrubs and colorful flowers known as a photographer's paradise.

The motorist driving northward through the center of the state will be richly rewarded with visits to the central metropolis of Orlando; Sanford on beautiful Lake Monroe; and on up the St. John's riverlands to DeLand, home of Stetson University; to Ocala and famous Silver Springs; to Gainesville made great by the great University of Florida, and on to Tallahassee, State Capital and home of Florida State University and Florida A. & M. Other fine institutions of higher learning are the University of Miamo and the University of Tampa, Rollins College at Winter Park, Southern College at Lakeland and several junior colleges and private schools. Florida takes its education seriously and is expanding its facilities to meet the demands of its mounting population and out-of-state students.

Florida, with all its advantages, holds magnetic attraction for old and young: for the scholar, the sportsman, the motorist, the businessman, farmer and those of the professions, offering almost unlimited opportunities in multiple fields of endeavor plus the advantages of favorable tax laws, friendly to business enterprise with the added bonus of what we believe is the world's best and most equitable climate. Native Floridians feel it is simply too good not to be shared with others. That is why we call it "The Nation's Florida."

Third International Conference on Soil Mechanics and Foundation Engineering

The Third International Conference on Soil Mechanics and Foundation Engineering will be held in Switzerland this summer. The first part will take place in Zurich on August 16–21 and the second part, August 22–25, includes a four days' tour through Switzerland to afford the opportunity to see not only points of interest for geotechnical and foundation engineering, but also something of the country's natural beauty. The final session will convene on August 26 at Lausanne on Lake Geneva. All correspondence relative to the Conference should be addressed to Dr. A. von Moos, General Secretary, Gloriastr. 39, Zurich 6, Switzerland.

Thoughts on Contemporary Problems*

By JOHN SLOAN DICKEY

President of Dartmouth College

President Dickey extended a cordial welcome to the members of the ASEE and said that he wished to speak for a few minutes about "the purpose of higher education and the reconciliation of what we are pleased to call the liberating arts and the technical, professional studies with which you are primarily concerned."

Mr. Dickey stated that his predecessors had dedicated Dartmouth to the proposition that its ultimate obligation is to human society. Mr. Dickey said if the ultimate obligation of the liberal arts college is to serve human society, the college must look out into that society and ask what is the central need of that society today.

"The central need of human society today is to bring into better balance the utter physical power which we now possess and the moral and political controls of that power. For the layman this need can be emphasized by considering that since 1900 the destructive power in the hands of men has increased by something like four million times. How much have we increased our moral and political controls over the use of such power since 1900? We need *better* balance between physical power and its moral and political controls. We are not confronted with the problem of discovering some new moral, political, economic or social truth. Indeed, if that were the case, the time factor is such that we had better just relax and have as comfortable a time as we can until this thing blows up."

"The central factor in the problem of getting this better balance is the time factor. The history of the human race indicates that, given time, men have been able to develop the moral and political controls necessary to the power that they possessed at any particular moment in history—whether the power was represented by slings, bows and arrows, gunpowder, or the six-shooter on the frontier."

Mr. Dickey suggested, however, that it is just possible "we have turned one of those few right angle corners in human affairs." He said, "Now, for the first time, men and nations have the power which can make their mistakes and their evil complete and irretrievable as far as this particular industrial civilization is concerned." If this is true, he said, then we can no longer rely on the proposition that time cures all things.

Speaking once more of the central need of society in relation to the purpose of the liberal arts college, Mr. Dickey said that men working in education must cling to the idea that the time factor in human affairs is not absolute and has never been absolute. "The time factor in human affairs is relative to the will and the capacity of men to serve the public good regardless of how they serve their own individual welfare. The liberal arts college is concerned more than any other institution of higher education with developing *both* the will and the capacity to serve the public good. The combination of will and capacity is the essence of leadership. Whenever your business, whenever your profession, whenever a

* A report of informal remarks delivered before the ASEE in Hanover, New Hampshire, June 25, 1952.

nation or any other human group has had a tough, large, seemingly insoluble problem, at the core of which was a time factor of urgency, the one thing that human experience indicates could be turned to is this thing which we call leadership. The principal historical justification for leadership is its utility in countering the time factor in human affairs."

In conclusion Mr. Dickey emphasized the importance of developing man's capacity for action. The will is useless without the capacity—"only as men see a way to do things can they sustain the will to do them. I suggest to you," he said, "that there's no profession more concerned than engineering in this industrial society with supplying the capacity for action."

Intensive Course in Automatic Control

The University of Michigan College of Engineering has announced two Intensive Courses in Automatic Control. The first is scheduled for June 15 to 20, 1953, inclusive, and the second for June 22 to 25, 1953, inclusive. The courses are intended for engineers who find it necessary or who wish to obtain a basic understanding of the field, but who cannot spare more than a few days for this purpose. The purpose of the course is to make it easier to learn by a coherent presentation of the fundamentals of modern automatic control and by providing a comprehensive set of notes to serve as a framework for further study.

The courses are built around the principles and application of measurement, communication and control. Course I will consist of the fundamentals in each of these fields and will include some fundamental work in non-linear systems. Course II will take up applications of the fundamentals to more advanced problems. There will be four hours of lecture each morning and three hours of demonstration in the afternoon. Extensive use will be made of computing, instrumentation and servo laboratories on the campus. The role of analog computing methods will be emphasized.

Further information may be obtained by writing to Professor M. H. Nichols, Room 1523, East Engineering Building, University of Michigan, Ann Arbor, Michigan. April 15, 1953 is the closing date for registration.

The Air Research and Development Program*†

By COLONEL O. G. HAYWOOD, JR.

U. S. Air Force

I appreciate this opportunity to present to the American Society for Engineering Education the broad aspects of the scientific program of the Air Research and Development Command, and to cover views of the Air Force as to its expected impact on university teaching and research.

The Air Research and Development Command is a relatively young organization. Top Air Force officials have long recognized the need for effective coordination and administration of the Air Force's far flung and widely-varied research and development activities. Three years ago, a special committee was appointed to study this problem. The committee was composed of university and industrial leaders, under the chairmanship of Dr. Louis N. Ridenour, then Dean of the Graduate School, University of Illinois. The Ridenour Committee recommended separation of research and development activities from materiel procurement—in other words, separation of responsibility for the quality of Air Force materiel from responsibility for the quantity procured. This concept was accepted by the Air Force, the Air Research and Development Command was established, existing research and development facilities and projects were assigned to it, and the command became operational as a major Air Force Command a year ago this Spring.

Many of you are intimately familiar with Air Force installations which have been consolidated to establish the Air Research and Development Command. Under the Headquarters of the Command, at Baltimore, Maryland, are eight field commands called Centers: The Wright Air Development Center, at Dayton, Ohio; Cambridge Research Center at Cambridge, Mass.; Rome Air Development Center, Rome, N. Y.; Arnold Engineering Development Center, Tullahoma, Tenn.; Flight Test Center, Edwards, California; Missile Test Center, at Cocoa, Florida and Alamogordo, N. M.; Armament Center, Eglin Air Force Base, Florida; and the Special Weapons Center at Albuquerque, N. M.

I would like to emphasize that, with a few exceptions such as certain studies in the bio-sciences at the School of Aviation Medicine, all research and development activities of the Air Force are under the command control of the Headquarters of the Air Research and Development Command at Baltimore. The entire program is prepared as a single, coordinated document, by personnel familiar with industrial engineering and research, university facilities and talents, and the Air Force's own laboratories.

The details of the program must remain secret, for obvious security reasons, and would be too complex for presentation here in any case. A few statistics on the general program may be of interest. The appropriation bill now before the Congress provides for direct research

* An address to the American Society for Engineering Education, at Dartmouth University, June 24, 1952.

† Provisions for support of publication of results of Government sponsored research were eliminated by the Congress before enacting HR 1180 as PL 557.

and development costs, in Air Force laboratories and by contract to other institutions, of approximately $600 million.

Allocation of Funds

A relatively small portion of this total is devoted to improvement of equipment and systems in the active inventory—our aircraft in operation in Korea; ground handling equipment; the multitude of items from blouses to B-36's which constitute Air Force materiel.

The bulk of the funds go into development of equipment and components which are combined into weapons and weapon systems to satisfy a specific operational requirement. For those not familiar with the term "weapons system," I might cite an example: a night jet interceptor complete with all its instruments, ordnance, fire controls, communications, and radar, together with the ground-handling equipment to keep it airborne and the ground electronic equipment to find the enemy and vector the interceptor into contact. The core of the program is oriented toward the requirements of weapons systems. The weapons systems match the operational responsibilities of the Air Force. The requirements of each system are determined from a weighted evaluation and judgment between the technical quality desirable for superiority over probable enemy weapons and the quality possible within the funds and time available.

A much smaller portion of the total funds is reserved for supporting research and development—the development of a new vacuum tube, or a better propeller, or a superior fuel.

Finally, a still smaller portion, actually about two per cent of the total, is devoted to basic research—fundamental investigations in those fields of the mathematical, physical, earth, and life sciences upon which rest our whole Air Force technology.

Going back to this figure of $600 million for research and development, we may break it down another way. Roughly, 10 per cent goes for direct costs of research and development laboratories of the Air Force, about the same amount goes to universities, and the remaining 80 per cent goes principally to industry. By direct costs of Air Force laboratories, I mean scientific equipment; laboratory supplies; and salaries of scientific, technical, administrative, and maintenance civilian personnel engaged in actual laboratory operations. Other costs of the laboratories are covered by other funds.

A portion of the 80 per cent going to industry is subcontracted to universities. Obviously such funds are almost entirely for applied research in furtherance of industrial requirements generated by Air Force contracts. The contract policies are established by the industrial concerns involved, and are not different from industrial-university relationships that have existed for years, except that the amount of money involved is greater than, say, twelve years ago before the Second World War.

About 10 per cent of the total research and development funds reach universities under direct contracts from Air Research and Development Command laboratories and offices. At the present time, obligations under active contracts with universities and university-affiliated research institutions total more than $120 million. The current annual level of support is approximately half this amount. The program covers a broad cross-section of American universities. It includes 107 universities in 33 states, the District of Columbia, Alaska, and Puerto Rico.

$120 million is a good deal of money, even to the Air Force. It is a good deal more to the universities. The Steelman Report to the President, Science and Public Policy, estimates that the total national research and development budget in 1930 amounted to $166 million. By national is meant not national government, but all expenditures within the nation—in government laboratories, in industrial laboratories, in universities. The national research total budget in 1930 is not greatly in excess of what the Air Force alone now has under obligation to uni-

versities. It is decidedly appropriate that both the universities and the Air Force study the impact of such work on the normal research and teaching activities of our universities, and take action to mitigate undesirable consequences.

Last November, the Air Research and Development Command established at Command Headquarters an Office of Scientific Research. I have been the Chief of this Office since it was organized, reporting directly to Lieutenant General Partridge, Commanding General of the Air Research and Development Command.

Need for Basic Research is Recognized

This Office was established in recognition that air superiority in the future is dependent upon adequate basic research in the present. The needs of national defense have created the present situation in which research and development expenditures of the national government exceed those of all of the rest of the U. S. economy combined. Government programs dominate, or at least greatly influence, the structure of the entire national research effort. In the past, the Air Force has concerned itself primarily with application of known scientific laws and principles to the technology of air warfare. It has built upon the existing foundation of basic scientific knowledge, it has depended on the universities to strengthen and expand this foundation. In the future, the Air Force must give more active support to basic research in those fields of science which provide the base for Air Force technology. This is the mission of my Office.

We approach this mission in two ways. First, we exercise general supervision over the basic research programs of all of the Centers. Second, we support directly a modest program of basic research in universities. (Perhaps I should define our meaning of the term "basic research." By basic research, we mean fundamental investigations which are supported because of their probable contribution to advancement of scientific knowledge when we have no specific Air Force problem or application in mind.)

There are many reasons why government funds should be made available in these times for support of basic research in universities. There is only one reason, however, why Air Force funds can and will be so used. The support of basic research in fields of science of interest to the Air Force is consistent with and in furtherance of the purpose for which the funds are appropriated to the Air Force—to develop and maintain qualitatively superior air power. If I may use the words of an almost antiquated economic theory, it is in the enlightened self-interest of the Air Force to support basic research in universities.

Let us return now to the university program as a whole and look at the effect on the universities. Of the present total of $120 million, slightly over half is classified work. However, three-fourths of the classified work is in six institutions, which have established contract research affiliates or separate projects so that the classified work does not intermingle with the academic teaching load.

About $55 million supports unclassified research in universities. Between one-third and one-half of this could be considered basic research, from the Air Force point of view and definition of the term. This portion of the program should be definitely beneficial to the universities, since it is simply adding to the type of research which is historically a role of universities and an essential adjunct to education at the graduate level.

A sample survey of basic research contracts indicates that each $100 thousand of Air Force funds supports in salaries four part-time predoctoral students, one full-time predoctoral research worker, two part or full-time postdoctoral workers, as well as part-time support of faculty members.

The number of predoctoral students receiving part-time Air Force support while pursuing graduate studies is considerably in excess of the 569 predoctoral students in the FY '53 fellowship program

of the National Science Foundation. The Air Force as a matter of policy encourages participation of graduate students on a part-time basis in Air Force basic research contracts.

Support Training of Graduate Students

Here again, this interest in supporting training of graduate students in the enlightened self-interest of the Air Force. These personnel are required for the effective prosecution of the research projects. Moreover, expanding the pool of trained scientific manpower in fields of science supporting the Air Force is strengthening the Air Force of the future. Few of these men will come into actual Air Force employment. It directly helps the Air Force, however, when these young scientists enter into industrial projects or university research for the Air Force, or simply join the pool of trained scientific manpower making other individuals available for Air Force-sponsored work.

The Air Force naturally expects to receive a portion of the university output of technical personnel. Approximately 450 second lieutenants will enter the Air Research and Development Command this June from university ROTC units. About two-thirds of these young lieutenants have scientific or engineering degrees. Judging from past experience, a few graduate students, including those who have been aided in their education by part-time employment on Air Force contracts, will accept commissions in the Air Force. A larger group will be required for civilian positions with Air Force laboratories. The Air Research and Development Command is planning a modest increase in requirements for civilian technical personnel over the next two years, of the order of 5 per cent each year. It anticipates no undue difficulty in meeting this requirement, although it would appreciate any assistance you gentlemen as educators can give in acquainting students with Air Force manpower needs. Incidentally, the Air Research and Development Command has just completed a brochure outlining the job opportunities with the command for technical personnel. Copies of this brochure will be mailed to universities within the next month.

In addition to payment of student and research workers' salaries, Air Force contracts finance research facilities, equipment, and supplies which are often of value in connection with university educational programs and would not otherwise be available. Finally, the part-time employment of faculty members, either in research projects, particularly during the summer months, or as consultants on research programs, adds to the emoluments of such personnel and helps to close the gap between the salary scales of universities and industry. I recognize that this last statement is applicable in varying degrees to different universities, is somewhat controversial, and is a matter for policy determination by the universities rather than the Air Force.

In keeping with standard university practices, the Air Force encourages publication of papers on its unclassified projects, and on classified projects to the extent permitted by security considerations. As Faraday said, there are three stages to research: to begin it, to complete it, and to publish it. Under government regulations, the Air Force must have a report on a research project before it can authorize final payment. However, in the interest of dissemination of scientific knowledge, and frankly to encourage better-written reports, the Air Force accepts in lieu of the final report, a copy of a manuscript covering the work which has been presented to a professional journal. I might add that the Air Force at the present time does not have authority to support such publication in technical journals. The Air Force is actively supporting HR 1180, a bill passed by the House and currently awaiting action in the Senate which would permit among other things support of publication of research results.

I have commented at some length on what the Air Force is doing to provide a more effective partnership with uni-

versities. I do not mean to imply, however, that we consider our part done or even well underway. We intend to continue study of this problem of strengthening the universities as research and educational institutions while we strengthen the Air Force as a fighting machine. For increased effectiveness in this Air Force-university relationship, we will unquestionably need increased participation of university personnel in planning and in management of the university program of the Air Research and Development Command.

I might add for the benefit of those not closely associated with the Air Force program that the Air Force has enjoyed for years the active assistance of university personnel. I have already mentioned that the Air Research and Development Command had its genesis in the report of a committee headed by Dr. Ridenour, then of the University of Illinois. Several other university personnel served on this committee, including Mr. Ray Woodrow who will preside at this afternoon's session on "Trials and Tribulations in University-Government Contract Procedures." My office has been aided in getting underway by the Panel on Physical Sciences of our Air Force Scientific Advisory Board. This panel, headed by Dr. George Kistiakowsky, Professor of Organic Chemistry at Harvard University, advises on the broad aspects of our program of basic research. Dr. Francis H. Clauser, Professor of Aeronautical Engineering at the Johns-Hopkins University, has associated himself closely with the office on a part-time basis, as my senior scientific advisor. Dr. Paul Flory of Cornell University is chairman of our Chemistry Advisory Committee. We are in the process of establishing similar committees for the other fields of science in which the Office of Scientific Research has comprehensive programs.

Active University Participation

I emphasize this active university participation in the formation of the Air Research and Development Command, and in the current activities of my Office, in the hope that many of you gentlemen will also be willing to contribute actively to the Air Force program. We must recognize that the universities of the Nation have become as essential to the Air Force research and development programs as Air Force operated laboratories. Research requires stability. This is a major problem in government-sponsored university research. Obtaining this necessary stability requires study and action by both the Air Force and the universities.

Three years ago, a faculty committee of the Massachusetts Institute of Technology completed an educational survey. The report starts with these words: "Final reports are the traditional monuments to the labors of committees, and too often serve only as a burying ground for ideas." In conclusion, I quote these words and express the hope that the ideas generated here today may bear fruit in more effective Air Force-university relations. The research requirements of the Air Force and the research and educational goals of the universities must be attained in harmony, not in conflict. We ask your active help toward this end, in our interest and in yours.

New and Specialized Laboratories of the Department of the Army*

By MAJOR GENERAL K. D. NICHOLS

Chief of Research and Development, Office of Chief of Staff, U. S. Army

It is indeed a pleasure to participate in this Panel discussion of "The Impact of Government Sponsored Laboratories on University Teaching and Research." The particular subject that has been assigned to me is "New and Specialized Laboratories of the Department of the Army." In assigning this subject your Executive Committee assured me that the title was broad enough to permit the widest of latitude in my comments. So, with that leeway, I would like to precede any discussion of new laboratories with a more general discussion of what we are trying to accomplish in the Army Research and Development Program.

The objective of our Army Research and Development Program is to exploit all avenues of modern technology to achieve the highest possible effectiveness for our ground forces, always keeping in mind that we have a paramount requirement that this effectiveness must be obtained with a minimum drain on our national resources. Our application of modern technology to war is not limited to the development of better equipment but we are also applying modern technical methods of analysis and research to determining the best way to utilize our equipment and manpower. Our efforts are being devoted to determining how we can accomplish the Army's mission with the minimum losses and at the minimum cost in dollars, talent and material.

Two of the primary problems involved are how do we reduce our losses and how do we make up for our deficiencies in manpower in facing Communist hordes by equipping our manpower with the most effective equipment and determining the best doctrine and techniques for its use. To achieve a reduction of losses is a real challenge to the military and to the technicians in finding ways and means of putting the Army on a par with the Navy and the Air Force. Analysis of losses in the last war and in the present fighting in Korea reveals that the ground soldier suffers some 80–90% of the total casualties.

As a result of this challenge, the Secretary of the Army and the Chief of Staff have been devoting a great part of their effort to insure that the Army Research and Development Program is given the proper emphasis. As an aid to insure proper emphasis. research and development in the Army was recently reorganized to place the Chief of Research and Development at high enough level in the Army organization to have direct access to the Deputy Chiefs of Staff, the Vice Chief of Staff, the Chief of Staff, and the Secretarial level of the Army. In addition, all parts of the General Staff are actively participating in the Research and Development Program. In addition to hardware research which remains with the Technical Services, greater emphasis is being given to operational research, research for development of new techniques, and basic research.

This reorganization is continuing down

* (Discussion at the Annual Meeting of the Engineering College Research Council of the American Society for Engineering Education at Dartmouth College, June 24, 1952.)

into the Army Field Forces where we are planning to set up a development organization for testing new weapons and developing new techniques and doctrines, as well as establishing a special weapons command for solving in the most expeditious manner the training, tactical and doctrinal problems related to Army use of atomic weapons and guided missiles.

Another objective of the Research and Development reorganization was to insure closer liaison between strategic planning and research and development. This is a two-way proposition. We must not only insure that our strategic plans for the future recognize the possibilities of our Research and Development Program but at the same time we must adjust and orient our Research and Development Program to be in accord with our strategic planning.

Utilization of all Talents Available in Primary Problem

In our efforts to achieve the most efficient weapons and techniques for using them, we recognize that one of our primary problems is how do we combine and utilize to best advantage all the talents available to us. In the development of a new weapon the optimum weapon is achieved when we utilize to best advantage the talent, experience and know-how that are available in the Army Field Forces which is the ultimate user, the Army Technical Services, industry and universities. No one of these groups by itself can achieve the best weapons nor can any one of these groups dictate what is the best weapon or the best way to use it. Like so many other things in life, accomplishment here rests on making the user, the Technical Services, industry and academic technicians work together as a team.

The variety of laboratories that the Army has and is building and the variety of our contracts illustrate that there is no one best way to achieve this optimum blending of talents. The procedures best suited for developing a rifle are not the best for developing a new or novel weapon such as the atomic bomb or the proximity fuze. The result is that we have various types of laboratories—some of them are government-owned and operated such as those with which you are all familiar as at Fort Monmouth, Aberdeen, and Edgewood Arsenal.

In addition to these old, well-established, government-operated laboratories, we have the relatively new laboratories at Camp Detrick, Maryland, operating under Chemical Corps jurisdiction, and the laboratories at Redstone Arsenal, Alabama, for guided missiles, operating under Ordnance jurisdiction. We hope to build a Quartermaster Laboratory at Natick, Massachusetts. In addition to government-owned and government-operated laboratories, we have created several government-owned laboratories that are operated by either universities or industries. In the guided missile field one of the most outstanding laboratories that is government-owned and university-operated is the Jet Propulsion Laboratory operated by California Institute of Technology in Pasadena. This laboratory, operated under contract and under the most competent direction of Professor Louis G. Dunn, has made outstanding contributions to our guided missile program. In a similar manner guided missile work has been conducted in government-owned and contractors' facilities by the General Electric Company and by Bell Telephone Laboratories. These are cited as typical examples and are not intended to be all-inclusive of installations or of our program. Also, the Army guided missile program represents the varied ways of contracting and allocating responsibilities in order to get the job done. For example, for one missile the Jet Propulsion Laboratory at California Institute of Technology has done the research, development and engineering, and Firestone Tire and Rubber Company is responsible for production.

For another outstanding missile Bell Telephone Laboratories and Western Electric Company have had complete re-

sponsibility for research and development as well as production. They have been assisted by Douglas Aircraft and other subcontractors. At Redstone Arsenal the Army Ordnance is utilizing many of the German scientists who were responsible for the German guided missile program during the last war. This civilian-military organization is assisted by several industrial contractors.

In addition to research and development on basic hardware items such as guided missiles, tanks, artillery, munitions, etc., wherein academic resources are being employed to assist the Research and Development Program, the Army has turned to the scientists for assistance in solving operational problems. Several years ago we asked The Johns Hopkins University to staff and administer an Operations Research Office, borrowing from educational institutions qualified scientists that we might have them apply technical analysis to our more difficult operational problems. I regret that we have to be in competition with education to get a qualified staff for the Operations Research Office but I can assure you that the end justifies the means. The ORO has already proved invaluable in furnishing analyses of operational problems to assist in important command decisions. It is surprising how an intuitive appraisal of comparable value of weapons and weapons systems can be reoriented by a careful, detailed evaluation of effectiveness, operating costs and required logistic support.

For example, it has long been the dream of every antiaircraft artillerist that we could develop a radar acquisition and fire control system so accurate that the first few rounds of any attack would result in a sure kill. We have analyzed a weapons system of this type, allowing a reasonable evaluation of the system capability and comparing it with World War II capability. Believe it or not, it can be demonstrated that under certain circumstances, the probability of getting a kill for a given dollar expenditure is lower for the fancy, very expensive system with radar control than it is for a system where those same dollars appear as additional weapons. Like comparisons are being made between expensive guided missiles and conventional artillery for air defense or tactical support. This is just another example of the sort of support our Research and Development Program receives from our higher educational institutions. It will be our continuing effort to use these resources in every way we possibly can.

Academic Resources Effectively Employed

There are many other ways in which academic resources can be effectively employed to assist the Research and Development Program. The Army has just recently decided to increase the scope of the operations of the Control Systems Laboratory at the University of Illinois where work is being carried out under an Army administered contract for the Army, Navy and Air Force. Here we are establishing a level of effort by stating the number of dollars per month we are prepared to apply—thus effectively establishing a laboratory of a certain size. We direct the technical effort with a committee of representatives of the three Services approving tasks for the laboratory as new ideas are evolved. This gives us a very flexible means of enlisting the support of these scientists. When an idea reaches the prototype stage, it can be removed and given by contract to an industrial concern, thus keeping the scientists busy with more fundamental problems, and using industry for the more prosaic problems of straight engineering.

Another use for academic assistance is in the Army-Navy-Air Force supported contract at the Massachusetts Institute of Technology where an Air Force administered contract is seeking to solve major problems in air defense. Here, also, a high degree of flexibility has been retained in the contract. Major shifts of direction and emphasis can be made without rewriting the basic contract.

In addition to research leading to equipment or techniques for using equipment,

the Army is also supporting basic research. Although I personally have never actively been involved in basic research, and as an engineer by training my inclination is to concentrate on getting practical results, my experience with the Atomic Bomb Project has made me realize the significance of carrying on basic research. Although the atomic bomb is perhaps the classic example of a formidable weapon springing suddenly from basic research, many other lesser examples could of course be given. As engineers we certainly all must realize that the progress in applied research and applied engineering is always dependent on building a broad foundation of basic research.

The military also recognizes the value of basic research and the Army has established a bsaic research committee at the General Staff level to foster basic research on all the Technical Services. In addition, the Office of Ordnance Research at Durham, North Carolina, was established to fill the ever-increasing need of Army Ordnance for the fruits of technical research. The Office of Ordnance Research sponsors basic research in those technical areas that have proven valuable to Ordnance in the past or that promise to be similarly valuable in the future. This work is carried out almost entirely by small contracts with educational institutions. The primary requisite of these contracts is the availability of an able scientific leader who can direct and control the work. We hope that every effort can be made to give full freedom to the technical personnel not only in selecting the areas in which they will work but in deciding ways and means and the scale of effort in investigating those areas. The Office of Ordnance Research is quite young, having been officially established only about one year. I am certain that as it matures it will become one of the Ordnance's most valued assets.

In the utilization of university scientists we still have many problems to solve. We fully recognize that the military utilization of university talent can not be permitted to unduly interfere with the education of future scientists and technicians. Moreover, we have no desire to eliminate the free-thinking in universities for it is this very free-thinking—or free-wheeling as it is sometimes called—that is one of the intrinsic values of university research. It is particularly of value when one recognizes that the very nature of government red tape tends to make government laboratories more conservative in their approach to solving problems. We need both approaches.

Contracting Procedures

In addition to worrying about the impact on the basic mission of universities, we in the military also have a long way to go toward arriving at acceptable contracting procedures and methods of coordinating the division of effort between various universities and industrial contractors so as not to create unnecessary friction and useless effort. For a good many years I have been exposed to the task of trying to coordinate the efforts of military, industry of various types, universities, labor unions, and in some cases plain ordinary housewives at isolated locations, and I can only say that to get any harmony at all out of these diverse groups requires a recognition that we are all different breeds of cats and must be handled accordingly. Perhaps some day we will develop a breed of military cat that knows how to handle such problems—certainly that is a task facing the Army today. So to those of you who have government contracts, all I can ask is your patience in bearing with us while we all learn to appreciate each other's talents and shortcomings. One of the worries that has repeatedly raised itself in the Research and Development Board is whether the continued expansion of the military Research and Development Program can be supported by the universities. We recognize that we are constantly diverting a greater and greater proportion of university talent to our military effort. Certainly a study of the record indicates a tremendous growth in military research. A review of the rec-

ords for the past 12 years indicates that the Army Research and Development Program has expanded some 20 times as compared to immediately before World War II. It is more than twice as large as our peak during World War II, and is some four times as large as the period immediately after the war when we were all more hopeful for a long period of peace.

Expand or Stabilize?

One of the real questions facing us is —can we continue to expand or have we reached a point where we should stabilize our effort? Certainly the problems confronting us all point to the desirability of an increased effort, but should we continue to increase this effort if the long term effect on our educational institutions is too serious. If we are faced with immediate all-out war the answer of course is more obvious, but we all hope that the result of our efforts in research and development and our armament program in general will be to reach a state where we not only can win a war if it is thrust upon us, but also that we may have the possibility of deterring war. Whether this effort will be a long one or a short one is very difficult to evaluate at this time. Certainly it must be weighed from year to year, and perhaps if we can utilize our funds and talent efficiently we can not only get the answer concerning the time and the degree of effort but we may also accomplish the major objective of avoiding war.

New ECRC Secretary

Virgil E. Neilly, Assistant Professor of Engineering Extension at the Pennsylvania State College, has been appointed Secretary of the Engineering College Research Council.

Professor Neilly, a graduate of the Electrical Engineering Department at Penn State, is a member of the American Society for Engineering Education and an associate member of the American Institute of Electrical Engineers. He has been honored by election to Phi Eta Sigma, Eta Kappa Nu, and Tau Beta Pi.

Professor Neilly's appointment was announced by Dean Eric A. Walker of the School of Engineering at Pennsylvania State College, who is Chairman of the Research Council. As Secretary, Professor Neilly succeeds John I. Mattill, now Director of Publications at the Massachusetts Institute of Technology.

The Engineering College Research Council, a unit of the American Society for Engineering Education, represents the research activities of ninety-eight leading engineering schools in the United States.

Should Engineering Schools Teach Engineering?

By THOMAS K. SHERWOOD *

Dean Emeritus, Massachusetts Institute of Technology

Engineering is sometimes thought of by educators as a collection of academic subjects constituting a curriculum. Others think of engineering as a way of life. Engineers are not walking encyclopedia, but men who do things. They are creators, designers, and managers, whose satisfaction in life comes from creative accomplishment. This is recognized by our form of engineering education, which is based on the principle of "learning by doing." Nevertheless, the engineering curriculum is designed primarily to teach men what they need to know *in order to start learning* something about engineering. It is really a pre-engineering curriculum.

It would seem that the basic tools of the practising engineer are five in number: concepts, principles, techniques, facts, and judgment. We teach the first four in formal classes, and hope that the student may acquire the fifth. The concepts include such things as temperature, heat, vapor pressure, and reversibility, which help an engineer to understand and to think. Principles include the chemical laws of combining weights, the first and second laws of thermodynamics, and Newton's laws of motion. Techniques include not only laboratory and industrial methods, but the technique of tackling a design problem, the use of the library, and the preparation of a good written report. The engineer must have a limited number of facts in his tool kit, but the straight learning of facts has always been emphasized less in engineering than in other curricula, and the last twenty years have seen a steady strengthening of the basic science at the expense of the empirical know-how or "handbook engineering" within the four-year curricula. But we have restricted our teaching primarily to the tools of the profession, and done little to introduce the student to the application of the engineering method to complex engineering situations. Referring to a similar list of "tools," the 1944 Report on Engineering Education after the War (3) states that "knowledge of these tools does not constitute ability to practice engineering."

The "engineering method" is more than a catch phrase. It involves the evaluation of a situation—a process seldom required in the solution of a typical ten-line problem assignment. It involves the selection of the appropriate tools—those applicable to the assigned home problem or quiz are usually indicated, or obvious from the context of the course. Very often it requires economic balances of a type which the student meets only in the most elementary form as an undergraduate. It usually involves the handling of situations without adequate data and without unique answers, in which conclusions based on judgment must be made and defended. These are so foreign to undergraduate instruction that students feel ill-treated when sometimes given an assignment with missing data, or one without a definite answer. These protected students experience a rude awakening in the cold world of engineering practice.

Examples

There are, of course, many examples of comprehensive design projects and other

* Professor of Chemical Engineering; Dean of Engineering, 1946–52.

techniques whereby the undergraduate is required to employ the engineering method in attacking real engineering problems, under the guidance of experienced teachers. Most such activities, however, are limited to a few undergraduates and the majority of the engineering students are not influenced.

M.I.T. chemical engineers engage in a comprehensive plant design problem, requiring cost studies and complete process engineering calculations for a chemical plant. But this is a graduate course. Last year seniors in electrical engineering tackled the design and promotion of a gas-discharge flash light for amateur photographers. This involved technical design, the question of the appearance of the product, a market study, questions of manufacture, financing, and advertising. But this was an elective taken by a few seniors. In mechanical engineering seven seniors did a group thesis on the improvement of a commercial vacuum cleaner. New fan blades and other parts were designed, produced by the manufacturers, tested and reported by the students. But we cannot get the technical assistance and several thousand dollars cash to support the theses of every seven seniors. At M.I.T. students get one of the finest of educational experiences in the Servomechanisms and the Instrumentation laboratories in working with creative teachers in the design and actual production of new mechanisms such as the Brookhaven pile's servo-operated control rods. But these again are graduate students.

One of the most intriguing possibilities along these lines is the plant design project engaged in by seniors from several engineering departments. Each group presents and defends its contribution to the complete project. In addition to the engineering experience, the student has the opportunity, rare to undergraduates, of learning to work as a member of a group. It is not known that this type of project is being carried out at the undergraduate level.

Educational experiences such as these, often available at the graduate but so seldom at the undergraduate level, represent the experience in *synthesis* for which purpose the four-year training in *analysis* is planned. But of greatest importance is the point that here is the opportunity for the engineering student, while still in college, to get some concept of the thrill of creative accomplishment, without which the college experience means little more than a four-year extension of the high school pattern. Where else will the student get an appreciation of the meaning of creative professional activity? In freshman physics? In applied mechanics? In courses in materials? Perhaps in a two-afternoon-a-week thesis in the second term of the senior year?

Our friends in architecture follow the project pattern, starting with second-year design. Somehow they are able to resist the temptation to require more and more subjects; a considerable fraction of the entire curriculum is devoted to design. Dean Hollister (1) has previously suggested that we may benefit from the example of the teaching of architecture. The 1944 Report (3) also refers to the system followed in architecture.

Objections Raised

Whether or not the comprehensive design project or other techniques of teaching the engineering method belong in the undergraduate program is certainly open to question. The 1944 Report gives one opinion—"Judgment matures only through experience, but introduction to the art of engineering and the development of judgment—in other words, elementary competence in the engineering method—can and should begin in college" (3). Many may argue that comprehensive exercises in the engineering method do not belong in the schools—that engineering schools should teach the tools of engineering but not attempt to teach engineering. I do not agree with this latter point of view, though I accept the fact that some will hold to it on principle. More, however, will conclude

that the objective is sound, but that such activities on any important scale are quite impractical within the limitations of the four-year undergraduate curriculum. The late President Wickenden wrote in 1929 that the limited treatment of creative engineering was "regrettable but inevitable" (2). The practical objections hinge on (a) the lack of qualified teachers for such an admittedly difficult task, and (b) the lack of time in a crowded curriculum.

I am not so sure the objectors are right on the first point. If the initial goal were to provide the equivalent of one full semester of the comprehensive project type of education, only approximately one-quarter of the instruction given by engineering department staffs would be involved. If a few imaginative teachers showed the way to the development of this kind of teaching, many others could follow their lead. Engineering faculties now include hundreds of men who have had wide engineering experience at a responsible level in industry, and many of these would follow such leadership with understanding and enthusiasm. Perhaps we could attract more such engineers into the teaching profession if our instructional pattern were not so completely compartmentalized into separate subjects, separated by artificial walls non-existent in engineering practice.

The second practical objection assumes that within the four-year curriculum there is now no material less important than the proposed project-type instruction in the engineering method—that it is certainly impossible to cut present material by the equivalent of one full semester. This is debatable—in fact it has been debated extensively in connection with the efforts in recent years to allot more time to the Humanities. But there is a difficult though possible way out—involving the killing of two birds with one stone.

Courageous Experiments Are Called For

The way out of the difficulty is illustrated by a recent experiment at M.I.T. Undergraduates in aeronautical engineering were offered an entirely new type of instruction in the second of two semesters in engineering thermodynamics. They were asked to design an air-conditioning system for a jet aircraft. Just that. First they had to learn something about jet aircraft, but they already knew a little. Why air-conditioning—for the equipment or the pilot? How much would the cooling load be? Why did it get hot? These questions led to a study of heat transfer, then concepts and theories of stagnation temperatures, a realization of the inadequate state of the art as revealed by the literature, and finally into problems of refrigeration engineering. At the end of the semester these students took the same final exam as those students who had taken the regular course in thermodynamics, and did as well. In other words, it *is possible to provide the creative engineering-project type of instruction without sacrificing the haloed "coverage" of "material" to any important degree.*

The idea of comprehensive projects and other schemes for instruction in the engineering method is certainly not novel. Both the 1940 and the 1944 Reports list this as one of the main objectives of the scientific-technological stem of the curriculum, and describe this objective in specific terms. The 1944 Report describes a course or subject designed with this particular objective in mind. It would seem, however, that too little has been done, and that the experiments have been on too small a scale. The objective cannot be attained by changing the instruction within the framework of discrete subjects, either by modifying existing subjects or by single new subjects. Really worthwhile results will be obtained only by the imaginative use of large blocks of student time, of the order of entire semesters.

To do much of this sort of thing is clearly a large order. But engineering education is in something of a rut, and courageous experiments are called for.

Except for the great strengthening of our programs through the application of more science and mathematics, there has been little fundamental change in two generations. The curriculum is still four years (with few exceptions) following high school; it is still made up of poorly-related separate subjects; and the subjects are mostly the same subjects, modernized, but taught in much the same way. The idea that engineering schools might also teach engineering suggests the challenge of a departure from tradition which, at the very least, would provide the student motivation so often lacking.

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College Notes

Dean S. S. Steinberg of the **University of Maryland** College of Engineering has been named adviser to the School of Engineering of the University of Puerto Rico at Mayaguez. He plans to visit the island commonwealth early in March to confer with university administrative officers and faculty members on the development of their engineering curricula and laboratory facilities.

* * *

The largest group of Special Summer Programs in the history of the **Massachusetts Institute of Technology** will be given at the Institute next summer. These special programs, designed for professional personnel from industry, government and educational institutions, will be given in addition to academic subjects from the Institute's regular courses and in addition to several technical conferences which have been planned in a number of fields.

* * *

A bequest of the late Norman W. Church of Los Angeles to the CALIFORNIA INSTITUTE OF TECHNOLOGY, together with gifts he made to the Institute a few months before his death January 7, will make possible construction in the near future of a $1,500,000 laboratory for education and research in the field of chemical biology. The laboratory is to be known as the Norman W. Church Laboratory of Chemical Biology. It will be joined to the present Crellin Laboratory of Chemistry and also eventually to the Kerckhoff Laboratories of the Biological Sciences.

* * *

Cooperative programs enabling a student to obtain degrees in both liberal arts and engineering have been arranged by **Stanford, Knox College,** and **The College of Idaho.** Selected students at Knox and Idaho will take a three-year liberal arts course at their college, followed by two years of specialized training at the Stanford School of Engineering. Upon successful completion of the five-year course, the students will be awarded a bachelor of arts degree by their college and a bachelor of science degree by Stanford.

Isn't This the Crying Need?

By WILLIAM W. ROGERS

Head, Dept. of Mechanical Technology, Long Island Agricultural & Technical Institute

Almost daily we read in our newspapers, magazines, and technical publications, hear on radio, and watch speakers on television all publicizing the great need for engineers. Occasionally, the great need is questioned, as in Time Magazine of April 21, 1952 a spokesman for the U. S. Steel Company reported that 75% of the jobs for which engineers were hired could be filled by graduates with B. A. degrees. The magic figure "80,000 engineers" is never accompanied by an equally important quota, of let us say, "400,000 technicians," and "1,000,000 semi-skilled industrial workers."

Just as surely as the low birthrate of the 1930's cannot be altered, the heavy demands of the military program ignored, and bad advice (about five years ago) to guidance counselors be recanted, we as educators for industry are doing collectively little to put forth a broad program to obtain students in training for all branches of industry. Some militant leadership is needed in our field. It is needed to assemble the forces of engineering, technical, and vocational education at all levels, into a solid group to develop a program to provide our future students.

Today we have no such comprehensive program. In the *Journal of Engineering Education*, September, 1951, Dean Hollister of Cornell University said, "The educational system that has come into being in this country certainly was not evolved after a preconceived national plan, as far as engineering and allied schools are concerned. Whereas abroad there is commonly a technical institute functioning in parallel with strong professional engineering education, there have been relatively few technical institutes in this country, leaving the burden of serving both needs upon the engineering schools." The relatively few technical institutes in New York State have met the same avalanche of personnel recruitment men as have engineering schools. Studies * have shown that for each engineering position there is need for four to twenty technicians.

We need a program that will fill our schools with students for all levels of industrial competency. Our present efforts (which center principally about the needs of the engineering school) only taps the surface. An overall program for students must go back farther than the high school, farther than the elementary school, and into the home. Through every communicative means it must be shown that a future in industry has respectability, profit, and great promise. No additional studies of needs are necessary; the Educational Policies Commission report,† Education for All American Youth is one which did the job well. What is needed is leadership. Consider the magnitude of the program of the National Safety Council; ours should be as broad and unceasing.

A strong program for industrial occupations would only strengthen the good elements in our present educational pat-

* Vocational Division Bulletin No. 228, Vocational-Technical Training for Industrial Occupations, U. S. Office of Education. (Superintendent of Documents, Washington, D. C. 40¢.)

† "Education for All American Youth," Educational Policies Commission, 1201 Sixteenth St., N. W., Washington 6, D. C. ($1.00).

tern at the elementary and high school levels. Well-educated high school graduates with a broad background in humanistic-socialistic studies, mathematics, and science, and an enthusiasm for technical work are desired in all levels of vocational, technical, and engineering positions.

The three principal fields of training for industry each work with industry but do not work together. Representatives of vocational and technical education meet together for mutual good as rarely as do the technical institutes and engineering schools. It would not serve our industrial needs at all to assume that one type of school should serve as a preparatory ground for another; there are fixed ratios of needs of engineers; technicians; semi-skilled workers which must still be met.

Let us be sure of this—there are great needs at all levels of industrial competency, and they cannot be met by meeting only the quota of engineers. Consider the case of those who enter industry with only two years of engineering education. Of one group studied,‡ about 70% stated positively that they felt that *lack of an engineering degree was no hindrance to success.* Again, from the April 21, 1952 issue of *Time Magazine,* "Today (the engineer) goes forth into a technician's world and an engineer's market." Technical schools can train its graduates to fill many positions for which engineering schools cannot. In many fields the technical institute graduate will be more successful, happier, and a better producer than the engineer. And until we resolve to approach our needs with an overall program, there will never be enough competent engineers, technicians, or semi-skilled industrial workers.

Our school population is growing at the elementary school level. Soon these students will be in high school and thinking of their future careers. By starting a campaign now, we can attain the future student body needed, and gather in many good students in the years before the large group born in the 1940's come into our technical and engineering schools.

What should be the principal elements of such a program? It should instill in the minds of young boys and their parents the concept that a future in industry is:

1. Financially rewarding
2. Respectable
3. Able to offer many unsurveyed horizons.

This we cannot do overnight; education is a process measured best by generations. Now is the time to plan for these generations. Now is the time to gather all resources. Now is the time to undertake a master plan for obtaining a student body in engineering and its allied branches—that will man our industrial enterprise today, tomorrow, and in the years we will never see.

‡ "Is Less Than Graduation Worthwhile?", Clement F. Freund, Dean, College of Engineering, University of Detroit, *Journal of Engineering Education,* September, 1951.

AMERICAN SOCIETY FOR ENGINEERING EDUCATION

NOMINATION BLANK

"ARTICLE XI, Section 3. (Election of Officers) By means of a form to be printed in The Journal of Engineering Education or in the preliminary program of the annual meeting, an opportunity shall be given to individual members of the Society to submit names of persons to be considered for said officers. These names, on the form provided, shall be sent to the Secretary of the Society not less than sixty (60) days prior to the annual meeting; and the Secretary shall submit the suggested names to all members of the Nominating Committee."

In order to make the election of officers of the Society as democratic as possible, members are urged to fill out the nomination form and return before April 1, 1953 to the Secretary, A. B. Bronwell, Northwestern University, Evanston, Illinois.

I nominate the following members of the Society for officers:

For President .....

.....

For Vice-President .....
(In Charge of General and Regional Activities—two years)

.....

For Treasurer .....

.....

Signed .....

Title .....

Institution .....

Date .....

The Co-op Prepares for Engineering*

By C. F. ARNOLD

Chief Engineer, Cadillac Motor Car Division, General Motors Corporation

My subject is "The Co-op Prepares for Engineering" and although these ideas will probably apply to other branches, they are based mainly upon my own experience as an *automotive* engineer.

My comments will cover: first, suggestions for classroom courses which should be given more emphasis; second, the main advantages which should be sought for in the shop periods; and last, some general comments on the advantages of co-operative education as it appears to me.

As to the courses which I think should be emphasized more strongly in the school portion of the course, it would be difficult to say which is most important but certainly the following group are near the top. One is applied mathematics. Far too many fellows leave school with the ability to solve differential equations but haven't the foggiest notion as to how they could be used to help themselves out of some practical problem—and this does not necessarily need be confined to the higher brackets of mathematics. We have a simple application of first degree simultaneous equations which enables us to determine the weights of the upper and lower end of a connecting rod much more simply than by the conventional weighing method.

Another is what we might call Dynamic Design—the mathematician would have a tough time justifying the modern crankshaft design, but it has developed along very sound principles For example, a great deal has been learned on handling or avoiding high stresses, which should be taught to the student.

Closely allied to this is the study of vibration Practically every part of an automobile is concerned with vibration in some way or another The crankshaft vibrates in bending and in torsion The entire power plant bends as a beam on its supports and can be excited resonantly at certain speeds. Example: We ran into this a number of years ago when we had a very hard to identify "boom" in the car at about 55 mph After a great deal of work, this was traced to a week flywheel bell housing which was permitting the entire power plant to flex in the middle It was excited by the propeller shaft and its natural frequency occurred at this 55 mph speed Once the cause was determined, it was fairly simple to stiffen the bell housing sufficiently to raise its natural frequency above the driving range of the car and thus eliminate the objectionable period. The propeller shaft must be very carefully designed to avoid critical periods and so on with the motor supports, the sheet metal reinforcements, the body mountings and the steering mechanism, to say nothing of the frame and suspension which are, of course, special problems in vibration dampening.

From my own experience, the study of metallurgy has probably been used more than any other course which I studied and a working knowledge and understanding of both the ferrous and nonferrous metals is more important today than ever. We should also include, and keep up-to-date, courses on the characteristics and uses of plastics, glasses, ceramics, rubber,

* Presented before the Co-operative Education Division of the A.S.E.E. at Michigan State College, Lansing, Michigan, June 27, 1951.

silicones and other new materials as they are made available for modern design.

Although I have not had the opportunity of checking this personally, I suspect that modern drafting room practice, as used in most plants today, is quite different from that which is taught in most schools and it might be well for the drafting instructor to periodically visit some of the more progressive design rooms in the industry to keep up-to-date on the constantly improving methods.

Sooner or later the successful man in any line needs training in effective speaking and I think that the earlier this is started the better, as it not only is helpful for public speaking but, to my mind, is a great deal *more* valuable in the day-to-day contacts in conferences and in the transmission of instructions to other members of the organization.

Some of the basic principles of human relations should most certainly be taught. I know of many very promising engineers, who were tops technically, that have failed to advance because of their ignorance of the importance of learning to get along with people. Every organization has its "problem children"—men who are extremely valuable in certain jobs but who must be handled carefully to keep them happy and with today's shortage of engineers, this is very important.

And last in this group, a knowledge of cost accounting is most important in today's economic race. The engineering designs must not only be good but they must be capable of being produced at a reasonable cost. The old wisecrack, that an engineer is a guy who can do for a dollar what any fool can do for two dollars, is certainly truer today than ever before.

Training in Industry

In the shop portion of the course, the co-op's program should be planned so that he covers everything from the simpliest type of work through to the most complicated operations. And he should be taught to try to obtain what we might call the shop atmosphere: the workmen's point of view and attitudes, their side of the labor question and their thinking on organized labor. He gets to see a side of the workmen which is rarely revealed to the graduate of a regular course even though he may be given shop trainee or apprentice courses. Starting as he does as a rank beginner, the co-op is taken in as one of them and does not meet the wall of difference which confronts the man who has taken a straight course and enters the shop as a "College Graduate."

The co-op should, if possible, obtain experience in all of the departments concerned in the manufacture of production automobiles: the foundry, machine shop, welding department, the press room, the plating department, and assembly work; he should have some inspection experience and then spent his last year in the engineering department. I realize that this much coverage is probably never obtained but it should certainly be the objective and if the total number of work weeks in the 5 or 6 years course is carefully divided and assigned, it should be possible to come close to this ideal.

Advantages

As to the general advantages of co-operative training, it certainly gives the man the opportunity to find out, at the earliest possible moment, whether or not he is really fitted to do what he thinks he wants to do. I talk to youngsters these days who have been over-impressed by the magic word "research" and picture themselves in a long smock, surrounded by electronic equipment and coils of blown glass, discovering some new form of energy; but soon quit and go home when they find out that they have to start helping somebody bolt together a base to support the stand on which some of this equipment is to be placed. Being able to get a taste of the kind of work which he has selected, while he is still able to change his course, is a tremendous advantage and I think your records will show that while the co-operative student may change from mechanical

to civil engineering or from chemical to metallurgical, once he graduates, he rarely changes his profession.

There is another intangible advantage in obtaining his shop work at the same time as his technical training, compared with the fellow who goes to school for 4 or 5 years straight and then goes out and gets experience. We might compare it to the advantage of intimately mixing the sand and cement before the mortar is prepared—it forms a bond which cannot be obtained in any other way.

Then there is, of course, the economic advantage of co-operative training. Many of us could not have obtained an education without the financial help which the work periods provide.

The co-op is much more likely to stick it out and finish his education than the student taking the straight course; seeing the alternative constantly before him in the shop, of men who have not trained themselves and are trying to advance without that distinct advantage, is one of the strongest incentives to complete his education. I know of many instances when men left a school period discouraged and ready to quit but returned from the shop period with renewed enthusiasm and a resolution to see it through.

Co-operative training gives a man a basic understanding and sympathy for the shop problems which he never forgets. In some plants there is downright enmity between manufacturing and engineering. The factory group thinks the engineers are a bunch of impractical, arbitrary, stuffed shirts who sit up in their tower and try to devise something more diabolically difficult to make, while the engineer looks down on the shop men as a bunch of uncivilized barbarians who never make anything like the drawings and then wonder why it won't work. Such attitudes are never found in co-operatively trained men, whether they wind up in manufacturing or engineering; they have a real respect for the other fellow and a sympathetic understanding of his problems and this is the only basis on which a continuing sound business can be built.

One of the turning points in my experience developed from such a contact. It was in 1938, we had just brought out a new V-16 engine and, while over in the shop, I noticed that a number of problems had arisen in its assembly. At the time, I was in charge of the dynamometer lab which had done much of the development on the engine, so I pitched in and spent several days in the shop explaining the new design and helping work out their problems. While there, the Works Manager and the General Manager stopped by and, as a direct result of this, when the new job of Production Engineer was established I was given the assignment. Perhaps any man would have done the same under the circumstances but for the co-op it was a natural reaction.

Co-operative training also gives him an appreciation of the serviceman's problems and of the importance of designing for accessibility and easy repair.

Need for broad knowledge

The young engineer should be sold on the value of continually broadening his knowledge. I am frequently asked by members of our organization "How can I get ahead?"—"What should I do to get a promotion?" Of course no two cases are exactly alike but in almost every instance I find that the following suggestions apply. Lets' take the job of Laboratory Supervisor as an example. It is assumed that we have several candidates, all ambitious, all having some leadership ability and having good technical training. If all of these characteristics were equal, the job would not necessarily be given to the best dynamometer operator but to the man who has best informed himself on all phases of testing. The Staff Engineer on chassis may not be the best specialist on brakes, or axles, or transmissions, but the man who knows most about *all* of them. In this day of specialization, it is easy for a man to get into a rut but that applies to his coworkers just as well and if he will take the trouble to learn something of the

other fellow's "rut," while doing well his own job, he will stand up head and shoulders above his competitors when the choice is made for a promotion. Just take the top job in any industrial organization—the General Manager—the first word of his title tells you what his responsibilities are. He must know Sales, Manufacturing, Purchasing, Engineering, Accounting and Personnel handling—but few men ever go through all these departments in their normal career. After the man became head of one of these groups, he was selected as General Manager because he, in addition to knowing his own job, had learned more about the others than anyone else, and that principle applies right down to the foreman of the smallest department.

This is good advice for any man on the way up, but for the co-op, with his basically broader background and training, it is a natural—and, aggressively used, is a success formula which I have never seen fail to get results.

Conclusion

So, as the co-op prepares for engineering, give him more courses which he can apply directly in his work, encourage him to get the full benefit of the "shop atmosphere" during his work periods and impress upon him the importance of continuing to expand the broad start which you have given him in his education, for, like a pyramid, a big man needs a broad base.

College Notes

The **University of Wisconsin's** new Chemical Engineering Building is gradually being put into full use on the UW campus as installation of its technical equipment is completed in its 10 laboratories. The building has three stories and basement constructed of concrete, lannon stone, and brick, and besides the 10 laboratories, it provides classrooms and offices and other special service and work rooms for the University's chemical engineering staff and students.

* * *

The Division of Applied Science of **Harvard University** announces the appointment of Dr. John H. Curtiss and Dr. Andre Guinier as Visiting Lecturers for the spring term of the academic year 1952–53. Dr. Curtiss is Director and Founder of the Institute of Numerical Analysis of the National Bureau of Standards. He is also a member of the National Research Council Committee on High Speed Computing Machines. He will give a course concerned with problems of numerical analysis. Dr. Guinier is Professor at the Sorbonne, and is internationally known for his work in the field of x-rays and metallurgy. His research laboratory is located at the Conservatoire National des Arts et Metiers in Paris. His lecture course at Harvard will be on the subject of x-ray metallography.

A Simplified Technique for Item Analysis*

By R. O. SWALM

Associate Professor of Industrial Engineering, Syracuse University

Introduction

The making of good tests is not an easy task—and after attempting to construct a good test a teacher naturally wishes to measure the success of his efforts and perhaps to build up a file of good test items. One of the techniques available to him is an item analysis to determine which item proved most useful in that particular test.

In this paper the scope and theory of item analysis will be discussed very briefly and then a simplified technique for item analysis will be presented. Finally a few brief remarks concerning the use of this technique will be made.

Item Analysis

Before anything can be evaluated, a standard against which it is to be measured must be established. In judging the effectiveness of various test items, two guiding principles will be used. The first of these is that, in order to most effectively differentiate between abilities throughout their entire range, items should range in difficulty from very easy to very difficult —ideally, at approximately equal increments of difficulty. The second is that each item should be useful in selecting superior from inferior ability in the field being measured.

Unfortunately, the implications of the first principle are denied, in practice, by a great many engineering instructors. The objective of too many teachers seems to be to make all items on a given test of equal difficulty, and generally with the expectation that the great majority of the class will answer between 55 and 95% of the items correctly.

Since it is extremely rare for a test to have an error of measurement of less than ± 10 percentage points (generally it is much higher than this) it should be obvious that there will be relatively few instances in which we can say that, based on the evidence offered by the test, one particular student is definitely superior to another. Certainly the probability of a man who obtained 85% being actually superior to another who obtained 75% is slight—and the probability of the reverse being true is far from zero.

How can this uncertainty be overcome? By deliberately setting out to spread the grades of the same group from about 10% to 90%! This will have an effect comparable to that obtained by using an air gauge instead of a scale to measure the diameter of a shaft. By so doing, we do not change the thing being measured (in this case a shaft), we do not change the *actual* error of measurement introduced by the human eye (on the air gage as on the scale, we can detect a difference of about one one-hundredth of an inch on the scale being read), but we will expand a small range of sizes to a large physical range on the air gage so that the error of measurement introduced by the eye is relatively less important.

In testing, it has been found that, by submitting items that range from the very simple to the extremely difficult, we can expand the range of percentage grades, that, under the traditional methods, would vary from 55% to 95% to the point

* Presented before the Educational Methods Division at the Annual Meeting of the ASEE, Dartmouth College, June, 1952.

where they vary from, say, 10% to 90%. This will have little effect on the error of measurement, so that the precision with which we can rank students is greatly increased. If our error of measurement is ± 10%, we are quite confident that a student who obtains 75% is definitely superior to one who obtains 50%. Of course, this means that we will have to use different standards in translating from numerical to letter grades—but to say that 50% is equivalent to a grade of "C" is certainly no less arbitrary (though perhaps less traditional) than to say that 75% is equivalent to "C". It requires some re-orientation in the thinking of both faculty and students—but as engineers we should surely be willing to re-orient our thinking in order to gain greater precision at no increase in cost.[1]

With regard to the principle that each item in a test should be useful in selecting superior from inferior ability, the obvious difficulty in determining the degree to which this objective has been met is the selection of a suitable criterion.

Unfortunately, knowledge of the relative ability of students is seldom present. Indeed, if it were, there would be little purpose in giving a test. This is not an insurmountable difficulty, however, for if it is assumed that the test as a whole is a valid instrument, each item can be measured against the whole test. This assumption will probably be reasonably accurate if the test maker has critically asked himself, "Does this test measure what it purports to measure? What am I trying to test for—knowledge of facts? Understanding of facts? Ability to apply principles in new situations? etc.," and then, "Does this test measure these abilities?"

In measuring each item against the whole test, the basic criterion may be stated as "As compared to those who do poorly on the test, do a significantly greater number of students who do well, answer this item correctly?" If they do, the item would appear to make a positive contribution to the whole test. If, on the contrary, more inferior than superior students choose the correct answer, the item is probably not useful in its present form. A danger signal has been raised—the item should be investigated. Further, if only a few more of the better students answer an item correctly, this may be attributable to chance and the item probably does not discriminate well between various levels of ability.

If the test maker is attempting to measure several different abilities, it should be recognized that he is in reality giving several different tests. Unless the correlation between these several abilities is very high (and it frequently is not) items in each of these different tests should ideally be evaluated against scores on that test alone.

The most useful measure of an item's ability to discriminate between different levels of achievement is the co-efficient of discrimination. There are several types of such co-efficients; one of the more useful bears the imposing name of "Tetrachoric," and this particular measure of discriminating ability will be used herein. Unfortunately, like the others, it is not simple to compute. Charts are available to simplify the work required, but even with these it is necessary to divide the test papers into halves, one containing the higher and the other the lower scores. Then the per cent of the students in each half who respond correctly to each item to be analyzed must be computed, the chart entered with these values, and the value of the coefficient of correlation read (frequently by performing graphical interpolation). This is laborious and still does not answer the question, "How large should this co-efficient be to be significant?"

For practical use, the teacher is not concerned with the actual value of this co-efficient—he need only know that it is high enough to be significant, or to indi-

[1] For a more complete discussion of the logic behind this concept, the reader is referred to an excellent exposition in Chapter II of Hawks, Lindquist, and Mann's "Construction and Use of Achievement Examinations," published by Houghton Mifflin.

cate excellent discrimination. If such information can be obtained with little effort, it will be used far more frequently than an exact value that can be obtained only with relatively great effort. It therefore seems worthwhile to propose a simple method which can be used to select items which have a high probability of showing good (or excellent) discrimination in future tests. This method will *not* offer proof that the remaining items should be discarded. This is impossible, both from a logical and a statistical standpoint. Careful consideration of such items before their re-use, however, is definitely indicated.

Development of the Proposed Technique

Families of curves showing the value of the tetrachoric co-efficient or correlation as a function of the per cent of students in the upper half who answer an item correctly (Pu) and the per cent of students in the lower half of the class answering the same item correctly (Pl) have been developed by Mosier and McQuitty [2] and improved by Adkins.[3]

These curves are plotted letting the ordinate represent the percentage of the upper 50% passing an item and the abscissa the percentage of the lower 50% passing the item, each increasing from 0 to 100%. The curve corresponding to $r = 0.00$ is the diagonal passing through the origin; all curves representing positive values of r are above this line, symetrical about the other diagonal, and increasing in curvature and in the distance of their midpoints (falling along the second diagonal) from the midpoint of the curve for $r = 0.00$ (as r approaches 1 the curves approach co-incidence with the left and upper sides of the square making up the chart). If, on the curve for any value of r, a tangent is drawn to it at 45° to the horizontal, the equation of this line will be in the form $Pu = Pl + Cr$ where Cr is the point where this line intersects the ordinate.

Rewriting this equation as $Pu - Pl = Cr$ and remembering the straight line described by this equation is at no point *lower* than its corresponding curve for r, it is obvious that if $Pu - Pl$ is equal to or greater than Cr, the corresponding value of the tetrachoric correlation co-efficient must be greater than the value of r.

Obviously the value of Cr will be a function of r, and this function can be determined empirically.

Better still, the data can be transformed into equations involving the actual number of students (N), the number in the upper group (U) (as measured by the whole test) who answered the item correctly, and the number in the lower group (L) answering the item correctly. These equations are of the form $U\text{-}L = Kr \times N$, where $Kr = f(R)$ determined empirically.

The remaining problem consists of determining appropriate values of r (and therefore Kr) as criteria of the discriminating ability of an item.

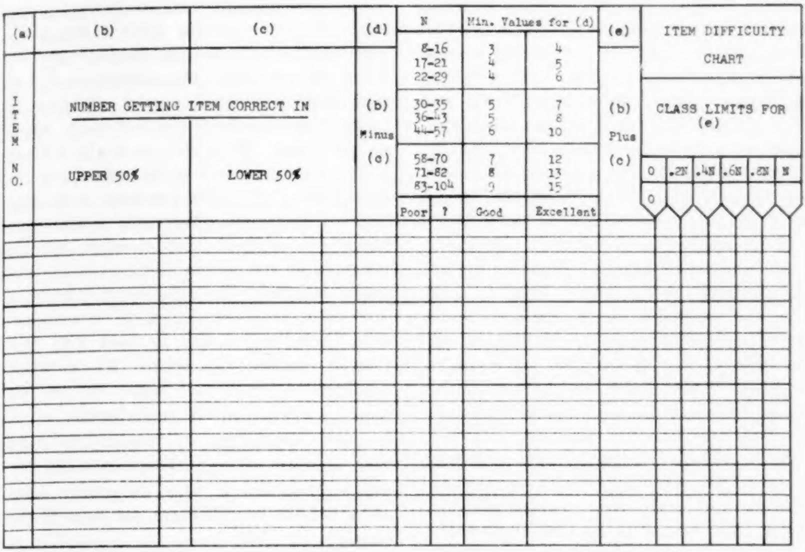
These criteria were chosen by arbitrarily defining the discriminating power of an item as good when it was significantly greater (at the 2 sigma level) than 0.1; as excellent when it was significantly greater (at the 2 sigma level) than 0.3.

Since the value of the standard deviation of the tetrachoric co-efficient of correlation is known,[4] and is a function of the value of r and the number of observations in the sample, critical values of $U\text{-}L$ for the desired criteria are readily obtainable as a function of N. These

[2] Mosier, Charles I. and McQuitty, John V., "Methods of Item Validation and Abacus for Item Test Correlation and Critical Ratio of Upper-Lower Difference." *Psychometrica*, Vol. 5, No. 1, March 1940, pp. 57–65.

[3] Atkins, Dorothy, "Construction and Analysis of Achievement Test," U. S. Government Printing Office, Washington, D. C., 1947.

[4] See Peters and Van Voorhes, "Statistical Procedures and Their Mathematical Bases," page 372, McGraw-Hill, 1940.



ITEM ANALYSIS FORM

Fig. 1

were obtained using graphical methods, and the continuous curve obtained was transformed into the discrete values appearing on the proposed form.

Use of Proposed Form

In order to make the application of the technique developed as simple as possible, the form shown as Fig. 1 was developed. While a description of the use of this form is necessarily somewhat involved, its actual use will be found to be quite simple.

The following instructions for use of this form have the virtue of completeness if not that of brevity:

1. Score the test papers in the usual manner.
   a. All correctly answered items must be clearly marked right and/or all incorrectly answered items clearly marked wrong.

2. Divide the test papers into an upper half and a lower half on the basis of their total scores.
   a. If there are an uneven number of papers, omit the median paper.
   b. If the median score appears on several papers, assign one half of these at random to the upper group and the other half to the lower group.

3. Fill out columns (b) and (c) on the form by tallying the *correct* answers on each successive paper; first for the upper group and then for the lower group.

4. For each item, enter in colunm (d) the difference between those in the upper half getting the item correct and those in the lower half getting the item correct (column (b)—column (c)).

Note that some of these results may be *negative*.

5. In the column headed "Minimum values for (d)" circle the number corresponding to the total number of tests. (For example, if there were 33 tests, 5 and 7 would be circled.)

6. If the value for an item shown in column d is negative, place an x in the

column headed "poor"; if the value is positive but less than the value circled above "good" place an x in the column headed (?); if the value is as great as the value circled above "good" but less than the value circled about "excellent" place an x in the column headed "good"; if the value is as great as or greater than the value circled above "excellent," place an x in the column headed "excellent."

7. In analyzing the results shown by this form, items marked x under "poor" are probably poor; those with x under (?) are dubious; those with x under "good" probably show good discriminating ability, and those with an x under "excellent" are those rare items which almost certainly discriminate well between superior and inferior abilities.

8. To obtain a rough item difficulty analysis, the total number of correct responses for each item (obtainable by adding the values shown in column (b) and column (c)) should be entered in column (e). Class limits for each 20 percentile range of item difficulty are obtained by entering the values for 0.2, 0.4, 0.6, 0.8 and 1.0 times N in the appropriate spaces.

9. For each item a check should then be placed in the item difficulty chart in the column bounded by the correct class limits.

10. The number of checks in each column should be totalled; ideally, these should be the ratio of 1:2:2:2:1 reading across the page. Any marked deviation from this ideal serves to indicate the direction of potential improvement of subsequent similar tests.

Limitations of the Proposed Form

There are two types of limitations to be recognized in using this proposed method for evaluating items. The first are those intrinsic in the basic theory, the second, those imposed by the approximations employed in this method. The first can well be sumarized in the quotations from Hawkes, Lindquist, and Mann's "Construction and Use of Achievement Examinations" which follow:

". . . to use the total score on *the test itself* as the criterion against which the constituent items are evaluated only enables one to select those items in a test that are individually most effective in measuring whatever the test as a whole is measuring. If the test as a whole is not valid, if it happens to be measuring the wrong thing, then the selection or elimination of items on this basis would only make the revised test a more reliable measure of the wrong thing; i.e., the test would become more reliable as it becomes less valid. . . . An index of discrimination, therefore, should be used with particular caution . . . where the criterion employed is the total score on the test itself. It may be of considerable value, in such situations, in identifying items that contain structural or technical imperfections, but it is a dangerous basis upon which to eliminate an item if the content of that item is acceptable in terms of other logical considerations" (pages 51, 52).

". . . it should be noted that the numerical value of the index of discrimination is not directly proportional to the desirability of an item for inclusion in a general achievement test. . . . In general, the best procedure seems to be to use the index of discrimination solely as a means of identifying seriously defective items, i.e., those with negative or very low indices, but not to employ it as a means of choosing between items showing reasonably high positive indices—the choice in the latter case to be based primarily upon logical rather than statistical consideration" (page 54).

The chief limitations imposed by the approximations used are:

1. As in any method based on significant differences, the results of this technique will enable the user only to state that certain items show a significantly good or excellent discriminating ability. Many of the remaining items might, if a larger sample were available, also prove to have good discriminating ability—but

this cannot be known unless more data are available.

2. The approximations on which the tests for discriminating ability have been designed are on a "fail-safe" basis. Stated another way, the criteria selected are, in many cases, more severe than would be demanded by more laborious exact methods. They are never less severe. These criteria are particularly severe from those items which are answered correctly by

a. 90% or more of the upper group
b. 10% or less of the lower group

3. The item difficulty analysis gives only a rough picture of the range of difficulty of test items. If there is a marked preponderance of checks in one or two of the columns, future attention should be given to writing items that will fall in the other ranges if a test is desired that will discriminate well between all levels of ability.

In the News

Thomas H. Chilton, Technical Director, Engineering Department of E. I. du Pont de Nemours & Company, has been named new Chairman of the Engineering Manpower Commission of **Engineers' Joint Council.** Formerly serving as President of the American Institute of Chemical Engineers in 1951 and then as Vice President of Engineers' Joint Council in 1925, Dr. Chilton has been active in the profession since graduating from college. Dr. Chilton graduated as a Chemical Engineer from Columbia University in 1922 and, after working in research, joined the E. I. du Pont de Nemours & Company in 1925 where he rose through the ranks to his present post.

Reginald James Seymour Pigott has been elected President of the **Engineers' Joint Council.** Mr. Pigott, former President of The American Society of Mechanical Engineers who is presently a consultant to the Gulf Research and Development Company, was recently retired as Chief Engineer, Director of Engineering Division, Gulf Research and Development Company in charge of engineering research. He graduated from Columbia University with a degree in Mechanical Engineering in 1906, returning a few years later to teach as professor of steam engineering.

Where Is the Challenge?

By J. F. LEE

Associate Professor of Mechanical Engineering, University of Maine *

The increasing loss of promising or clearly established engineering educators to permanent positions in industry represents a trend with grave implications for the future of engineering education. Replacements of equal capability are becoming progressively more difficult to find, and there is, of course, little assurance that the replacements themselves will remain in the profession for long. Since this condition appears to be widespread, it is worthy of the most critical examination. Should the trend continue or take a turn for the worse, it is apparent that eventually there will be a general dilution of the quality of engineering instruction. The difference which exists between academic and industrial salaries is blamed entirely by the casual observer who resigns himself to a situation for which little relief can be forthcoming in the foreseeable future. However, a more studied observation reveals that far more compelling factors than that of salary alone are involved in the ultimate decision of the engineering educator to leave the teaching profession.

Views of Former Educators

Beyond doubt, a great deal can be done outside of salary matters to provide a solution to this most real and serious problem in the opinion of engineering educators from various parts of the country who had recently left the teaching profession. Without exception, the former engineering educators interviewed readily admitted they had entered engineering education with the full expectation that the salary scale would be lower than that of industry. Some had even left industry for lower paying teaching positions. But they had expected teaching to offer advantages outweighing the financial considerations. Clearly then, something had happened in these cases to disturb the balance. Further examination revealed that in most instances the fault could be found in the complete or partial failure of the profession to provide the expected advantages. What advantages these men expected but did not find can be generalized by the following statement. Engineering teaching was expected to be an exciting and challenging experience providing a genuine feeling of accomplishment, requiring responsible decisions, and affording ample time and opportunity for professional development. Instead, engineering teaching was found to be a dull and slavish routine, stifling to the imagination and equally frustrating to creative ambitions, devoid of serious responsibility, and, in the final analysis, leaving nothing to the individual teacher but a feeling of growing incompetence as an engineer. It should be emphasized that the two preceding statements represent a composite view of the group interviewed. Nevertheless, enough of the elements were evident in any single case to make the statements fairly characteristic. One must agree that what was expected of the profession was reasonable and indeed desirable. Certainly engineering teaching has the inherent capacity to fulfill all that was expected of it by these former teachers.

Much was said by the people interviewed about the need for time and op-

* Now at North Carolina State College, Raleigh, N. C.

portunity for professional development. Therefore, it appears appropriate to review in what ways it was expected that professional growth could be attained. The means selected varied widely among the persons interviewed. Among those means stated were: research, keeping abreast of current developments in the field of major interest by extensive reading, part-time engineering practice, contributions to the professional journals, textbook writing, improvement of pedagogy, and participation in the activities of the professional societies. It will be recognized that all of these means provide tangible evidence of one's professional growth—a rather significant observation.

In seeking the causes for the disillusionment in engineering teaching, it becomes painfully evident that lack of responsibility and lack of time and opportunity for professional growth were the primary ones. All the disillusioning aspects of engineering teaching appeared to be either indirectly or directly traceable to these primary causes.

As for responsibility, it was felt that engineering teaching certainly did offer many responsibilities. The difficulty existed in the fact that the teacher was not permitted to assume responsibilities that are rightfully his. Often the individual teacher had no voice in formulating academic policy. In some instances, the curriculum and even the course contents were dictated by the department chairman without even so much as consulting the faculty concerned. Sometimes teachers were arbitrarily assigned to teach courses without consideration for their interests and talents. In an extreme case a teacher might find himself assigned to teach a course in which he was not at all interested merely to plug a hole in the teaching schedule. Obviously, such practices cannot foster a feeling of responsibility on the part of the teacher.

Closely related to responsibility in engineering teaching is that of professional growth. Whatever the means selected for professional growth, it is evident that time is a condition precedent to its achievement. In this connection, the most roundly condemned detriment to professional growth is that of loading the teacher with an excessive teaching schedule both in point of hours, number of students and numbers of courses. This practice is objectionable because it leaves the teacher little or no time for professional development. Where excessively large classes are involved and no assistance provided, the routine chores incident to teaching absorb such a disproportionate amount of the teacher's time that the joy of the classroom experience is largely obscured. With time at such a premium, there appears to be a common tendency to neglect reappraisal of course objectives and for the course work itself to settle down to a lifeless routine. It is not too difficult to understand that under such conditions teaching becomes a dull and slavish routine stifling to the imagination.

Views of the Writer

Much can be done by engineering schools to reduce teaching loads even when financial conditions do not permit increasing the staff. This can be done by a critical examination of the entire curriculum with a view to eliminating some courses and consolidating others. This should be done with the attitude of increasing the quality of teaching at the expense of the quantity. Aside from the core curriculum, some courses are found in the curriculum only because tradition places them there. Perhaps these should be eliminated. Often a large number of elective courses are offered. Perhaps this is a luxury in which the institution is not financially equipped to indulge. Some courses overlap each other so that consolidation into a single course may be feasible. Again, a course may meet five times per week when the course objectives can be adequately met in three meetings per week. In some instances it may be entirely feasible to consolidate two or more divisions or sections of the same course into a single division. A part-time assistant could be provided to

reduce the burden of checking homework, etc. if the resulting division includes a great many students. Laboratory and shop courses should be carefully scrutinized. These courses represent a considerable investment in building, machinery, equipment, and materials which, many times, is inconsistent with the returns. This is particularly true of shop courses and to some extent laboratory courses where the object is to test heavy machinery.

The result of incorporating such changes would be a reduction in contact hours both for teacher and student. This reduction would be beneficial to both since the student would have more time to spend on the courses taken, and, similarly, the teacher would have more time to improve the quality of his teaching. With more time to spend on his courses, the student can be expected to show a higher standard of performance. Therefore, though the number of courses would be reduced, the quality of learning and teaching would be greatly improved. This would seem to be a much better investment of available funds and time.

With time available, most of the means to professional development may be pursued by the engineering staff. It would be a rare individual who could follow all of the avenues available. However, a forceful staff could be expected, collectively, to take advantage of every means at their disposal. Therefore, some research, part-time engineering practice, and participation in the activities of the professional societies should be going on. To carry on these phases of professional development, the opportunity as well as the time must be provided.

Research for student and faculty participation should not only be encouraged, but financially supported by the institution. A large appropriation is not always necessary for fundamental research and the rewards in the way of vitalizing teaching more than repay any expenditure made. It must be stressed that research should not be regarded as a faculty hobby, but as an essential third dimension to teaching and learning. A successful program of fundamental research will create opportunities for sponsored research.

Consulting Work

Part-time engineering practice gives perspective to engineering teaching besides assisting the faculty members financially. This is highly desirable when few members of the staff have had responsible experience in industry prior to entering teaching. Obviously, such part-time engineering practice should not be permitted to encroach on academic duties, but a reasonable amount is highly beneficial to the staff. Where opportunities for engineering practice are limited, much improvement can be realized if the institution itself makes a concerted effort to attract such work for interested staff members.

Participation of staff members in the activities of the professional societies should be encouraged and financially supported by the institution. This is not to suggest that the dues of staff members be paid by the institution, but attendance at a national meeting of at least one professional society yearly and local meetings might be profitably underwritten. These meetings afford an excellent opportunity for teachers to exchange ideas with other people in engineering. This exchange brings fresh ideas and concepts to the campus. Many ideas for improving teaching techniques, broadening of outlook, improvement of course objectives and gaining of professional recognition are a direct reward for participation in professional society activities. It is clear that the institution itself also shares in these rewards.

The survey showed a need for active responsibility on the part of the engineering educator. It is a grave indictment of the teaching profession that these former educators, in their experiences, were not permitted to assume serious responsibilities. Certainly professional responsibility is a distinguishing attribute one expects to find in any true profession.

Furthermore, in the denial of professional responsibility lies the cause of which the other dissatisfactions enumerated are merely the effects. Given responsibility, a faculty is in a much better position to work out its own salvation, so to speak.

One might well ask then what specific responsibilities should be given to the faculty. Space does not permit a detailed discussion of the collective and individual responsibilities which should be given faculty members. Generally speaking, the faculty should be given full responsibility in those areas in which it is collectively most competent to exercise responsibility and in those other areas essential to maintaining complete freedom of expression and action. Full faculty responsibility is needed in determining the objectives of the various disciplines of study, the curricula for attaining these objectives, and the development and efficient use of faculty talents in supporting the curricula. In order to maintain complete freedom, the faculty must be responsible for determining its own membership, emoluments, promotions and the apportionment of available academic funds.

Conclusion

Engineering teaching offers a clear challenge when it is recognized that the engineering educator is both engineer and teacher. When the engineering educator cannot grow as an engineer, it is inevitable that he will fail as a teacher. The challenge becomes increasingly more clear in the mission of engineering education to develop in students intellectual curiosity and engineering skill, a desire to accept broad responsibilities, the ability to think analytically and critically, inventiveness, a true sense of values and human understanding. To recognize this challenge, the engineering educator must experience it in his own life and to meet the challenge he must continue to grow in professional stature all of his life. To stand still is to fail.

Acknowledgment

The writer wishes to express his indebtedness to the many colleagues and former colleagues in engineering education who have contributed to the preparation of this paper, and, in particular, to Dean Ashley S. Campbell for many valuable suggestions.

First Iowa Thermodynamics Symposium

Recent developments in thermodynamics will be considered at the First Iowa Thermodynamics Symposium to be held April 27 and 28, 1953 at the **State University of Iowa at Iowa City.** The symposium will deal in particular with processes involving heat and mass transfer. Applications of the topics to be discussed will be found in the fields of jet engines and many other phases of gas dynamics. The symposium is designed for persons in the academic field and in industrial research engaged in advanced thermodynamics.

For further information write to

Dean Francis M. Dawson
College of Engineering
State University of Iowa
Iowa City, Iowa

Subject Admission Requirements of Engineering Colleges*

By M. I. MANTELL

Chairman, Department of Civil Engineering, University of Miami

The catalogs of 126 engineering colleges were used by the writer to tabulate the subject admission requirements during the years 1949–50 and 1950–51.

* Presented at the Annual Meeting, Southeastern Section, American Society for Engineering Education, April 11, 1952, Clemson College.

TABLE I

TOTAL PRESCRIBED ENTRANCE UNITS ENGINEERING COLLEGES, 1949–51
(126 Institutions)

Number of Institutions	Number of Units Prescribed
3	0.0
1	2.0
2	2.5
3	3.0
5	3.5
3	4.0
2	5.0
3	5.5
8	6.0
9	6.5
13	7.0
4	7.5
20	8.0
2	8.5
9	9.0
11	9.5
14	10.0
3	10.5
3	11.0
3	11.5
2	12.0
1	12.5
1	13.5
1	16.0
Total 126	Median 8.1

These data are summarized in Tables I and II. Required units which were specified to be from one or more of several broad fields of study of from a choice of more than two subjects were not listed. Institutions allowing a choice of two subjects were not included in the zero unit column of either subject.

The trend in entrance requirements from 1895 to date shows a considerable change in the number of different subjects being specified, the number decreasing from approximately fifty-three to thirteen. Of the more common entrance subjects, algebra has shown very little change in the percentage of institutions requiring it during the approximately fifty year period. The subjects of physics, drawing and social studies have shown a gradual decline, since 1895, in the percentage of institutions requiring them. The percentage of institutions requiring plane geometry, solid geometry, chemistry, English, and foreign languages was higher in 1924–25 than in 1895, but decreased again by 1949–51; the sharpest decrease being in foreign languages. Trigonometry was the only subject showing a gradual increase during the entire period.

In terms of Carnegie units, the median number of prescribed units has decreased from 9.1 in 1924–25 to 8.1 in 1949–51. One institution presently sees fit to prescribe the entire high school program, thereby increasing the range of number of units prescribed from a range of 5 to 13.5 in 1924–25 to a range of zero to 16 at present.

TABLE II

SUMMARY OF ENTRANCE REQUIREMENTS FOR ENGINEERING COLLEGES, 1949–51
(126 Institutions)

Subject	% of Institutions Requiring Indicated Units						
	0	½	1	1½	2	3	4
Plane Geometry	2	0	97	0	0	0	0
Pl. Geom. or Adv. Alg.	—	—	1	—	—	—	—
Algebra	2	0	6	65	27	0	0
Adv. Alg. or Sol. Geom.	—	3	—	—	—	—	—
Solid Geometry	38	53	0	0	0	0	0
Sol. Geom. or Trig.	—	6	—	—	—	—	—
Trigonometry	61	32	0	0	0	0	0
Trig. or Adv. Alg.	—	1	—	—	—	—	—
Physics	55	0	29	0	0	0	0
Physics or Chem.	—	—	16	—	—	—	—
Chemistry	70	0	14	0	0	0	0
Biological Science	99	0	1	0	0	0	0
General Science	99	0	1	0	0	0	0
Science*	33	—	24	—	2	—	—
Science or For. Lang.	—	—	—	—	1	—	—
Foreign Language	79	0	0	0	14	2	0
For. Lang. or Soc. St.	—	—	—	—	3	1	—
Social Studies	51	0	36	0	8	1	0
Drawing	98	0	2	0	0	0	0
English	14	0	0	0	2	65	19
Health-Phys. Educ.	99	0	1	0	0	0	0

* Required units in addition to other science, when others are specified. Thirty-three per cent of the institutions do not require any type of science.

Articulation of High School and College

A tabulation of subject admission requirements becomes far more meaningful if it is also possible to determine to what extent the admission requirements are articulated with the college work in each institution. The extent of this articulation may become more apparent if reference is made to certain college courses related to the high school courses required for admission. Table III shows a summary and comparison of the high school entrance and related college course requirements.

From this table it appears that trigonometry is the subject which the colleges believe can be most effectively taught at the high school level; that is, sixty-five per cent of the forty institutions requiring high school trigonometry show their satisfaction with the high school treatment of the subject by not requiring it at the college level.

High school algebra is accepted, without college algebra, by forty-one per cent of the thirty-four institutions requiring two units of algebra for admission. The other entrance subjects (except plane and solid geometry, which are not given for college credit) are required, by the great majority of the institutions to be taken at the college level regardless of whether or not they were taken in high school. In some few instances special sections, carrying a smaller number of college credits are indicated for students having the high school subject; a few institutions indicate that special examinations may be taken which, if passed, may substitute for the college course.

The institutions which are willing to accept high school courses in algebra and trigonometry without their college equivalent tend to be those institutions which can be highly selective in admissions. However, none of these institutions will accept high school chemistry or physics in lieu of their college equivalents; nor do those institutions requiring high school physics and chemistry tend to require less semester hours in college, as may be noted from the range of credits shown in Table III.

Evaluation Of Admission Requirements

The records of 190 engineering students at the University of Miami were used in attempting to evaluate the subject admission requirements which would be most likely to affect success in the engineering school. Comparison of the college grades of matched pairs of students, one who had not and one who had taken the particular high school subject, were used as the measure of relative contribution of each entrance subject towards success in the engineering school. The pairs of students were matched initially by using equivalent percentile scores made on the American Council on Education Psychological Examination for College Freshmen. Grade point numbers of five for A, four for B, three for C, and two for D and one for F were used.

These data are shown in Table IV. The highest critical ratio of 2.67 was in the instance of chemistry—indicating a superiority (significant at the one per cent level) of those students entering with high school chemistry. Students entering with high school advanced algebra showed a superiority (significant at the three per cent level) in college algebra. Similarly students entering with high school trigonometry, mechanical drawing and physics tended to make higher grades than those without the high school background for the equivalent

TABLE III

SUMMARY OF COLLEGE ENTRANCE AND RELATED COURSE REQUIREMENTS
(126 Institutions)

Subject (H. S. Units)	No. Instit. Require	Instit. Req. in Coll.		Range of Coll. Sem. Credits
		Number	Per cent	
Algebra (0)	3	3	100	3 to 3.3
Algebra (1)	7	6	86	0 to 5
Algebra (1½)	82	74	90	0 to 5.3
Algebra (2)	34	20	59	0 to 5
*Trigonometry (0)	86	86	100	1.8 to 3.3
Trigonometry (½)	40	14	35	0 to 3
*Physics (0)	89	89	100	6 to 15.3
Physics (1)	37	37	100	6 to 16
*Chemistry (0)	108	108	100	4 to 12
Chemistry (1)	18	18	100	6 to 10
Drawing (0)	124	123	99	0 to 7.3
Drawing (1)	2	2	100	2 to 3.7
English (0)	18	18	100	6 to 12
English (2)	2	2	100	6 to 9
English (3)	82	81	99	0 to 16
English (4)	24	24	100	2 to 18
*For. Language (0)	106	1	1	0 to 12
For. Language (2)	17	0	0	— to —
For. Language (3)	3	1	33	0 to 4

* Includes institutions allowing a choice of subjects.

TABLE IV

SUBJECT COMPARISON OF COLLEGE GRADES
(Matched by A.C.E. Scores)

H. S. Course	College Course	No. Cases	Grade Pt. Mean With H. S. Course	Grade Pt. Mean Without H. S. Course	Critical Ratio
Adv. Alg.	Algebra	106	3.72	3.32	2.19
Adv. Alg.	An. Geom.	96	3.21	3.02	0.98
Adv. Alg.	Calculus	90	3.31	3.36	−0.23
Pl. Geom.	Trig.	50	3.52	3.16	1.16
Pl. Geom.	An. Geom.	48	3.21	2.96	1.00
Pl. Geom.	Des. Geom.	50	3.56	3.56	0.00
Pl. Geom.	Calculus	44	3.00	3.50	−1.73
Trig.	Trig.	146	3.82	3.55	1.50
Trig.	An. Geom.	120	3.23	3.07	0.90
Trig.	Calculus	120	3.28	3.43	−0.75
Sol. Geom.	An. Geom.	132	3.32	3.18	0.78
Sol. Geom.	Des. Geom.	152	3.74	3.43	2.07
Sol. Geom.	Calculus	130	3.44	3.38	0.33
Drawing	Eng. Draw.	150	3.95	3.84	1.05
Drawing	Des. Geom.	150	3.53	3.47	0.38
Physics	Physics	104	3.34	3.30	0.27
Physics	D.C. Mach.	62	3.19	3.23	−0.16
Physics	A.C. Mach.	42	3.38	2.86	1.79
Physics	Mechanics	58	3.38	3.19	0.83
Physics	Thermo.	44	3.23	3.50	−0.90
Physics	Stren. Mat.	44	2.77	3.05	−0.88
Chem.	Chemistry	148	3.39	3.07	2.67

basic college course—although the differences were not very significant.

However it is interesting to note that in most instances as the matched pairs moved into more advanced college work, the superiority of those with the high school background course decreased and even changed into the negative. Although the differences are not very significant, the data show such tendencies as students performing better in calculus for not having had high school trigonometry and worse in thermodynamics for having had high school physics.

A biserial correlation between entrance subjects and all 2086 college courses evaluated resulted in a biserial r of 0.07; the biserial r for 986 courses above the freshman level was 0.01—which indicated practically zero correlation between entrance and college subjects.

Such results seem inconsistent with what one would logically expect; however, subjective discussions with many of the students and faculty involved revealed a possible explanation. The students with previous high school instruction, when finding themselves in the same college class as those without previous instruction in the subject, tend to become overconfident and rely too much on previous knowledge. There is a tendency to slight the work as much as possible; repetition of much of the subject matter results in the course becoming tiresome, distasteful, and destructive of interest—fostering careless

habits of work. The students without previous high school instruction usually found it necessary to take their work more seriously, found it of greater interest and developed good work habits—which might account for a superiority in the advanced work.

Summary and Conclusions

Historically, subject admission requirements seem to have been those subjects which the colleges considered a necessary part of education, yet which could be handled adequately by the preparatory schools. Differences of opinion as to which subjects are a necessary part of education, differences as to which subjects can be done adequately by the preparatory schools, and the spontaneity of the development of American education, have resulted in the wide variation to be found in present subject admission requirements.

The 126 engineering colleges studied are apparently in complete agreement about five of the usual subject admission requirements being a necessary part of education; algebra, trigonometry, physics, chemistry, and English are required by every one of the colleges. They are, however, in considerable disagreement as to whether these same subjects should be taken in the high school only, college only, or in both high school and college. In all other listed entrance subjects there are disagreements as to whether or not they should be required at all, and if required, the location of training varies. Trigonometry and algebra are the only high school courses frequently accepted in lieu of the college equivalent; and these are accepted by only twenty per cent, or less, of the institutions whose catalogs were studied.

The engineering colleges, having specified admission requirements, do not seem to maintain a consistent policy in regard to the synthesis of the required high school courses with the college program. Certain engineering schools will require high school courses in some subjects and not require courses in these subjects at the college level. The same school will require other courses in both high school and college; and require still other courses at the college level only, regardless of whether or not the subject was taken in high school. The engineering schools which have no specific admission requirements are consistent; but consistency which apparently ignores or places little value on previous training is hardly sufficient.

The engineering colleges, in all probability, have found it difficult to be consistent or liberal in their acceptance of preparatory training because of the wide variations in the preparatory training and the usual emphasis in the preparatory schools on consumer instead of professional use of mathematics and science.

There seems to be no objective evidence validating the subject admission requirements which have been established for the various engineering colleges. The evaluative data presented in this study represents the results as found in a single institution; however, lacking contrary evidence, this data seems to allow the inference that (as similarly has been shown by many studies of liberal arts college admission requirements) there are no particular high school courses which lead towards success in the engineering school.

Engineering is based upon mathematics and the physical sciences, and an interest in and aptitude for these fields is important if an individual is to be a success in the profession. However, there is little point in the individuals' taking a full scientific program in high school to the neglect of other courses at least equally important. It would seem desirable for the engineering schools to advise entrance preparation with goals of: the building of a balanced background of general knowledge, discovery of the fields in which the individuals' interests and aptitudes lie, and a flexibility of program to allow the longest possible delay in making the final choice of, educational and vocational goal.

There seems to be evidence indicating that it might be preferable to require the

secondary training to be primarily in cultural or general education, instead of the traditional entrance requirements emphasizing mathematics and science. This would allow a depression of much of the non-technical portion of the engineering curriculum down into the high school, relieving the essentially crowded college program.

While the nation faces such a serious shortage of students entering the engineering colleges it might be well to consider interest and aptitude, above high school background, in selecting the students for admission. It would be difficult to estimate the number of potentially excellent students who have been denied admittance to engineering colleges because their interest in engineering developed too late for them to acquire the specified subject admission requirements, requirements based upon theories which apparently do not conform to fact.

Further Studies Needed

A study to determine the number and type of high school courses which would most efficiently indicate interest in and aptitude for engineering.

Additional experimentation on the feasibility of accepting high school courses in algebra, trigonometry, physics, chemistry and drawing in lieu of their college equivalents; or of giving college level courses in these subjects in the high school (the original intention of admission requirements).

A study of repetition of subject matter at the college level. This might be done by noting the effect of experimental groups taking upper level courses without the usual prerequisite of the basic course.

A study to determine whether or not adequate general education could be attained by greater emphasis on general education in engineering college admission practices, and by a more broadly integrated technical curriculum.

Additional evaluative data of current admission practices at other institutions, similar to that shown in Table IV, to supplement the data presented herewith.

Reserve this date . . . .

June 22-26, 1953

ANNUAL MEETING

UNIVERSITY OF FLORIDA

GAINESVILLE, FLORIDA

An Outline of Certain Processes of Reasoning in Research

By HENRY JAMES MASSON

Assistant Dean, Graduate Division, College of Engineering, New York University

The tremendous growth of research in the last thirty years has directed attention to its organization, management, and procedures. Because of the large sums of money, facilities, and personnel involved, and the desire to use these effectively and efficiently, examination and analysis of all procedures in use are constantly appropriate. Although a substantial literature is developing in the area of the management of research and development, the strictly technical literature of the various experimental sciences is almost barren of specific information concerning research procedures, except occasionally a vague reference to the scientific method without, however, amplification as to how it is used as part of the research process. However, in the field of philosophy and logic, there is available an extensive literature on the scientific method, but comparatively few students, planning a career in scientific research, elect courses in these fields as part of their formal training. When such courses are elected, there may develop a feeling of frustration or nonapplicability of subject matter, due to the abstractness of treatment. Many of the more philosophical writers on the subjects are not experimental scientists, and as a result, their language, illustrations, and approach may seem unfruitful to the eager young scientist interested in research.

Such frustration is neither necessary nor desirable. The modern concept of the scientific method, when properly considered, includes a multiplicity of sequences from an awareness of a problem to be solved to its successful conclusion and constitutes a disciplinary and directive philosophy of substantial value. We are concerned here, however, only with certain complex reasoning processes and their influence on the design of experiments and the selection of an experimental path leading to the solution of a problem.

Because of the appeal of research as a means of satisfying the curiosity of individuals and the desire to add to our knowledge of man and his environment, an increasing number of individuals are entering the field and are beginning to learn something of its philosophy and practices. This paper has been prepared in order to stimulate more extensive study by this young group of the literature related to the scientific method in general, and that of logic in particular, and at the same time, to present certain aspects of the methodology of research from a fresh viewpoint. Although these remarks are directed principally to this new group, the experienced investigator may find here and there a point of interest or basis for reflection. An effort has been made to winnow some fundamental principles from a vast amount of material and establish a framework for use in the design of experiments. It has been undertaken with apprehension, because of its departure from the standard presentation and the somewhat unrestrained interpretation and application of classical concepts. Certain ideas will be presented by means of arbitrary, diagrammatic representations, which have been introduced, because most researchers have high structural visualization, and, therefore, may give clarity to the subject.

Instances and Their Treatment

All fields of knowledge employ certain terms to described particular concepts. Various expressions from the field of logic will be used frequently and defined as they occur. One of these, of immediate interest, is the term "instances," which may be defined as any single fact pertaining to a thing, a physical or chemical property, an attribute, or event, which may be investigated scientifically and used to form an hypothesis or theory. A related number of instances may be grouped so as to form a phenomenon, or several groups combined to give the phenomena.

Through chance observation and as the result of designed experiments man has learned various facts. Over the course of time, these facts have been verified, experimentally or otherwise, and allowed to accumulate to form a reservoir or storehouse of knowledge. It is from this accumulation that man, by varying degrees of sagacity, has chosen those single instances, or combination thereof, which intuitively he suspects will lead to a solution of a problem.

Classification

Among the various traits which characterize investigators is the desire for classification—the ambition to bring order out of apparent confusion and establish a basis for convenient use and understanding of facts and their relationships. The desire for an orderly arrangement of facts—a form of "factual tidiness" is inherent in the make-up of the true scientist who wants to have his knowledge organized in a readily available and usable form. Neatness and apportionment are essential to the peace of mind of the scientist, so that his reasoning processes will be unencumbered by any disturbing disarray. Scientists are not content with facts when seen in isolation.

A mere collection or accumulation of instances—facts—does not constitute a science any more than a pile of bricks is a house or other useful structure. Since research is a form of human action which results usually in the discovery of new facts, a sound and fruitful method must be found to group, or bind, the facts together for useful purposes. The aptitudes of the investigator are concerned not only with discovering new and isolated facts, but should go beyond, and be so developed as to extend to the perception of wholes or patterns and consequences thereof.

As classification is an important element of reasoning in research, a few comments may be helpful to indicate its significance. Classification is a mental process carried out by an individual and consists of noticing or detecting certain similarities in attributes or qualities of things or phenomena considered in determining the classification. Or, classification may be described as the process of recognizing or identifying at least one trait or point of similarity shared in common by a number of instances or phenomena, and mentally associating these in a single group or class. The system of classification used may be based upon established or acceptable concepts or a working definition tentatively postulated for purposes of exploration. A classification may be depicted by a diagram, chart, figure, or in tabular form, as, for example, in the Periodic classification of the chemical elements.

In making the classification, an appraisal of value may be applied. It is rated of high value if there are many significant points of similarity and of low value if there are only a few similarities. The more points of similarity the more homogeneous and satisfactory will be the classification.

It is a matter of common knowledge that some individuals, on rare occasions, and more frequently in the case of experienced investigators, have the uncanny faculty to select, from a vast array of diversified instances, those having certain common similarities and bring them into a given classification. In some cases, based upon their selections and reflections, prediction may be made of what will probably be observed in a designed experiment or indication of the path to be followed toward the solution of a given problem. Apparently, detecting similar-

ities or likenesses is, in some aspects, more difficult than recognizing dissimilarities. In any case, the attempt to establish order among facts is a difficult task at which few succeed significantly. It cannot be reduced to a set of procedures which, when faithfully followed, will guarantee success. Classification will be considered later as part of the process of hypothesis formation.

Preliminaries to Experimental Research

A number of preliminary procedures are usually involved prior to the physical design of any experiments as, for example, the application of dimensional and statistical analysis. We are concerned at this point, however, only with certain procedures which usually come before the application of these important mathematical tools. One of the first steps in a research, in which the objective is clearly defined, is to determine which elements of the solution are available in the literature, but have not as yet been correlated or treated as part of the approach to the solution of the designated goal. The procedure to be immediately described applies particularly to the individual who is just about to begin his first research and who, although well grounded in the fundamentals of the broad field of the research, has not worked sufficiently long in the limited area of the research to have become familiar, as part of his working knowledge, with the particular instances that are involved.

It is well to realize that the purpose of carrying out an investigation is based upon the desire to add to knowledge, irrespective of whether or not the results are to be applied immediately or perhaps in the future. In any case, the researcher is operating at the frontiers of knowledge and hopes, through a successful solution, to expand a limited portion of these frontiers.

One of the initial steps undertaken by the researcher with a problem to investigate is that generally known as the "literature search," the mechanics of which may be represented graphically as follows—Fig. 1:

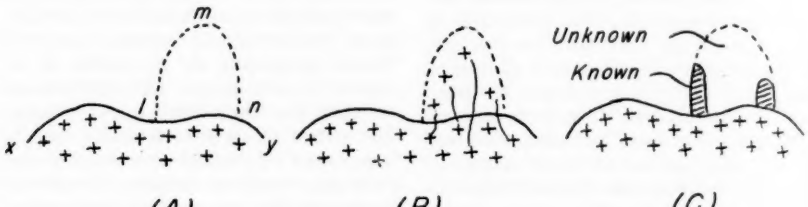


Fig. I

In Fig I–A, the solid line xy represents an arbitrary designation separating the area of knowledge, represented by crosses, from the unknown area. The dotted line lmn indicates a part of the unknown area circumscribed by the objective of the research. That is, if the investigation is successful, the new frontier of knowledge will be represented by a solid line xlmny. The boundary line xy is indefinite, located in a penumbra region and positioned by the skill (knowledge) and experience of the investigator. The line lmn is more so, the whole being a tentative arrangement for more solid construction. In Fig. 1–B, the instances from the known area, which the investigator suspects are part of the solution to the problem, have been transferred in a purposeful manner to the proposed area of investigation and thereby to begin the population of the region to

be added to knowledge. Fig. 1–C represents a segregation of related instances in the new area, thereby disclosing, both in magnitude and nature, known portions and unknown gaps to be filled. In other words, as a result of a careful study of the literature, it is disclosed that what was thought at first to be an area of which nothing definite was known now reduces to one of which certain portions are more clearly defined and other areas which must be investigated experimentally to develop the necessary information for completeness and inclusion within the new frontiers of knowledge.

Hypothesis Formation

This leads to a consideration of certain mental processes related to the design of an experiment and selection of experimental paths toward the solution of the problem. Whereas the various processes of classification operate on a certain intellectual plane, the intensive exercise of the same general analytical aptitudes can, in certain groups of individuals, give rise to syntheses and inferences of importance through the processes of reflective thinking and reasoning. In analyzing these processes, we may use a graphical approach, but with objectives and consequences of an heuristic nature.

It has been suggested that by means of classification a working basis may be established for extending the frontiers of knowledge. Occasionally, certain individuals, capable of varying degrees of significant thinking, and under free will, economic and other pressures, have gone an important step beyond classification and through uncanny insight, sometimes referred to as a flash of genius, discernedly take instances from this, that, or the other field, which, when fused together, result in a formulation which may be used as a basis for further exploration—the hypothesis.

Although the term hypothesis is frequently used in research parlance, it is desirable to review briefly its formulation, significance, and importance in the sequences of research procedures. An hypothesis is defined as a comprehensive but tentative interpretation of certain phenomena, to be considered as possibly true until there has been an opportunity, experimentally or otherwise, to bring all related instances into comparison. The initial hypothesis, pending verification, may be regarded as a "working" hypothesis, so that it may serve for immediate purposes of correlation and suggestive of a method of solution of a given problem. It is a tentative guess, or a scaffold, to aid in the construction of a more permanent structure.

A good hypothesis should: (1) bring together, in a simple manner, a given number of instances and interpret the connection between them; (2) be fruitful —fertile—that is, suggestive of significant deductions which are testable; (3) be comprehensible and not inconsistent.

In describing the creation and use of hypotheses, several terms are used. Two of these, induction and deduction, present difficulties in defining, because of the complexities involved and the evolution of interpretation which has taken place over the course of time by many minds. Both are concerned with thought processes. In its simplest form "induction" may be described as the process of reasoning whereby a selected group of instances are synthesized into a hypothesis and "deduction," the process whereby consequences are inferred from the hypothesis. On the basis of the foregoing, it has been advanced that induction is the reverse of deduction, but this is only true in the sense of convergence and divergence as illustrated by what follows. Many thought processes are both in fact inductive and deductive, depending upon the point of view during interpretation.

Classification has been treated as though it was an independent operation on the mind which stopped at mere classification. Actually, in many cases, while the process of classification is in process, the mind is not only seeing relations between instances, but also a possible interpretation of some phenomenon—that is, forming an hypothesis. The two opera-

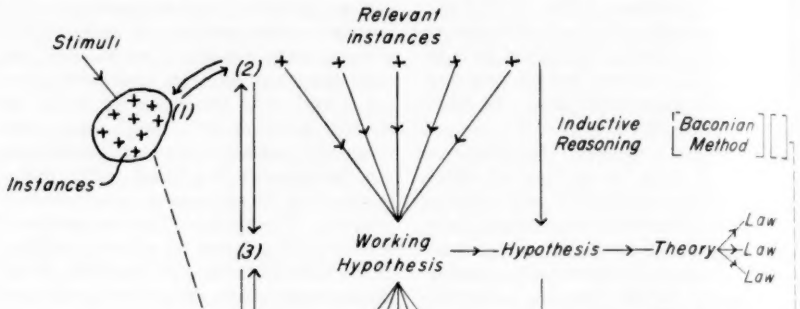


Fig II

tions may proceed simultaneously, so that in certain cases, particularly in new fields, the two processes are inseparable.

The relation between the processes of classification, inductive reasoning, hypothesis formation, deductive reasoning, and inferences is shown graphically in Fig. 2.

The above tends toward oversimplification. It is a condensation product which could readily be expanded to encyclopedic proportions. In the abridging process, certain concepts have been submerged and fine shades of meaning blended in the microdiagram.

In any case, it is not an expression of reasoning in the nature of a final product, but rather a mobile equilibrium product or condition in dynamic harmony with the state of knowledge at the time of formulation and the grasp of relations by the reasoner at the time of reflection. It consists of a multiplicity of reversible mental processes involving the sagacious selection and rejection of instances and consequences until a usable, consistent, fertile, and workable hypothesis is established which the mind (tentatively) feels is valid and which appears to give promise that it will be helpful in attaining the objective. However, the type of mind we are describing is probably never completely satisfied, but continues the process of selection, sorting and joining facts (jig-saw fashion) in an attempt to construct a composite picture in which all parts fit. One has no measure of the conscious or subconscious trials and errors which have taken place on a mental blackboard of some investigator until a flash thought—a mental leap (inductive)—points the way toward a simple formulation (hypothesis) in which all relevant instances are harmoniously absorbed or consolidated. It is a method of approximation. Hypotheses are tentative and cannot, in many cases, be exhaustively verified. Therefore, the frequent use of the word "probable" in connection with hypotheses.

Reasoning Process

In the beginning of the reasoning process, interchange of instances takes place between (1) and (2) (Fig. 2) until a combination or classification is attained

which is amenable to inductive reasoning. The next procedure, resulting in a hypothesis, is represented by the interaction between (2) and (3). These operations or thought processes may proceed instantly, or extend over varied and sometimes long periods, depending upon the complacency of the conceiver. However, such a mind, once started, and perhaps in a state of mental momentum is not contended to stop at (3). Whether, as indicated, through an idea momentum or vision, one may suspect consequences of the generalization or hypothesis. This leads to the process of deductive reasoning and the proliferation of consequences as represented by step (3) to (4). If, as the result of deductive reasoning, the consequences appear illogical, improbable, impossible, unreasonable, or contrary to experience and scientific law, the mind (the true scientific and unbiased) re-examines each deduction, reasons and modifies the hypothesis, until eventually complete harmony exists between (3) and (4). In this process, it may be necessary, and usually is, to examine all aspects. In other words, before the mind is satisfied, complete inferential agreement must exist between all phases and stable equilibrium prevails between stages (1), (2), (3), and (4).

Due to the limited comprehensiveness of the normal intellect, all consequences of an hypothesis are usually not deduced by a single mind and confirmed by recourse to memory. Additional significant deductions may be suggested by co-workers. All consequences are, therefore, listed and confirmation sought in the literature or experimentally. This brings us to an important observation. As the result of the foregoing treatment of instances, a new and unsuspected experiment to be tried may be indicated, or even a new field for research suggested. As indicated, a good hypothesis should not only weld together, in homogeneous agreement, a given number of instances, but should also suggest consequences of importance. Such consequences, when confirmed experimentally and their validity established, become instances to be added to the storehouse of knowledge and form the basis for a further expansion of the frontiers of knowledge.

The greater the number and impressiveness of instances included initially, the broader and more fundamental will be the resulting hypothesis. If based upon a sufficiently comprehensive number of instances and confirmed by an adequate number of experimentally proven consequences, the initial "working hypothesis" assumes the status of a valid hypothesis, and upon further confirmation, gives rise to various theories. If, over a long period of time and exposure to testing, no exceptions are found to a given relationship, a law of science may be formulated.

Laws of Nature and Science

A law of nature is an order or relationship detected in nature by some human observer based upon his investigations of an area of nature. It is a simple statement of facts, which may, in some cases, be expressed in mathematical form. The laws of science, in general, are not directly concerned with specific things, but rather with abstractions from them. For example, the law of gravitation is concerned with the forces acting between bodies, but there are numerous physical and chemical properties about which the law is silent, or uncommunicative. A law of nature is a summarization, or integration of a number of facts, the relationship or significance of which may be explained or clarified by a theory.

The nascent hypothesis and deductions therefrom are, up to this point, the product usually of one mind with its limitations, inadequacies, and importantly, prejudices. The originator, having exhausted all combinations and processes of reasoning and confident of his conclusions, and having faith in the integrity and sympathetic understanding of his fellow workers and the mutual desire for the advancement of knowledge, exposes and discloses the results of his reasoning processes by publication or otherwise.

Now the whole process begins anew. Compatible minds, interested and expertly familiar with the field of knowledge involved, dissect, analyze, reorient their views and allow an independent reasoning process free rein to evaluate the results of the creator of the new hypothesis. If we look upon the original hypothesis as representing equilibrium, we now find, unless all who study it agree with the premises and conclusions, that conditions (criticisms) will be advanced which have the effect of disturbing the equilibrium, which, in turn, will result in a shift to a new equilibrium (modified hypothesis). The extent of the resulting modification of the original hypothesis will depend upon the nature of each criticism and the number of confirming investigations involved. If, in time, general agreement of a modified hypothesis is reached, the resulting product will probably be superior.

Because of the interest developed, study of the hypothesis does not cease at this stage. Other minds, ordinarily not concerned with the field of research represented by the hypothesis, become interested and see applications in their particular field, and undertake investigations to determine its applicability. This transfer to another field may result in further modification. And so it will be seen that any hypothesis may undergo a sort of fission process.

At times, several rival hypotheses may be extant. Under these circumstances, a crucial experiment (experimentum crucis) is undertaken. It is a critically designed experiment to provide data with which one hypothesis is consistent and which is inconsistent with another.

A given number of instances may be selected to constitute a particular field of knowledge. The number of such instances may be large. One investigator may choose a certain group of instances and formulate an hypothesis while another investigator may choose another group from the same field and formulate what appears to be a different and unrelated hypothesis. But this is not necessarily so. All the instances involved in each case came from the same classification and from the nature of the classification process must have had some characteristics in common. This leads to the suspicion that both hypotheses are related and may be integrated into a single super-hypotheses. This development is illustrated by the contributions of Copernicus, Galilei, Newton, and Einstein.

There remains another situation which illustrates a still different mechanism of reasoning and which has been very fruitful as a means of formulating a working hypothesis to aid in the experimental design of some investigation or establish a basis of explanation for consequences not verifiable experimentally. In the cases studied thus far, the conscious mind is the one considered as functioning. We must give some consideration now to the role of the subconscious mind, although the distinction between the two is very indefinite. In this discussion, the subconscious mind is considered as exerting an effect when the body is completely dissociated from environmental factors disturbing to thinking and engaged in the automatic operations involved in the performance of familiar actions. While in such a state, and in search for a solution to a given problem, instances may be assumed which are not found in any literature or recalled from memory, and with intuitive faith in the reasonableness of the assumptions, the mind proceeds inductively to create an hypothesis and deduce consequences. The consequences may be constructive or fantastic. On the basis of such assumptions, substantial advances were made by earlier thinkers. This is illustrated by the kinetic molecular hypothesis.

The foregoing suggests another approach to hypothesis formation. This is the use of analogy. We may not observe a direct or structural relationship of instances to form an hypothesis, but there appears to be similarities from which others may be inferred. An analogy is a resemblance of relations which may be used for reasoning and from the likeness in certain respects we may infer that other and more important relations exist.

We refer to the flow of liquids as

analogous to the flow of electricity, the structure of the atom as analogous to the solar system and cybernetics reasons by analogy between the mechanisms of control and of communication in the animal and various mathematical machines Such analogical reasoning may be fruitful and help to visualize relationships, but there are dangers. We must, however, distinguish between circumstantial evidence and direct evidence which may lead to a false analogy. Analogy invades and influences our thinking and, although helpful in research, it should be used with caution and not allowed to lead to hasty generalization.

There is a last approach used occasionally and not always looked upon with favor, but, nevertheless, it may indirectly result in valuable contributions and may give some encouragement to the novice and act as an expedient to the experienced investigator. This is the "wild" experiment. The impression exists, and soundly, that the larger the accumulation of instances (knowledge) of the investigator, the greater the probability of his success in solving a given problem. But this is not necessarily so. Too much knowledge may lead to complacency and too much faith in the inviolability of generally accepted hypotheses, theories, or laws, and may result in the rejection of any suggested experiment which is an apparent conflict with them. Valuable discoveries were made by men who did not know they were violating some established theory. Such reckless suggestions leading to "wild" experiments have resulted in unusual discoveries. It is pleasant to have a deduction confirmed experimentally, but it is an experimental result which is at variance with theory, which may be productive of new knowledge and new fields to explore and which point to a path for the advancement of civilization.

Conclusion

In conclusion, it should be emphasized that hypotheses usually have a short life, theories come and go, but the facts with which they are concerned remain the same. The properties of benzene have not changed since it was first discovered, but the suggested arrangement of the atoms in the molecule, the interpretations of the formula and the various theories advanced to explain its action have changed—but again, not the properties.

Although an hypothesis may be rejected in due time, its formulation may not have been a complete waste of time and mental effort for experience and a study of discarded hypotheses have shown that when such hypotheses meet the usual specifications and are properly worked upon, they frequently produce more useful results than unguided observations. In fact, a constructive advancement has been made when new experimental evidence indicates the untenableness of a given hypothesis and it is replaced by one more in accordance with the newer evidence.

No scientific law or theory has ever given an explanation of why anything happens, that is, what makes it happen. They explain how things happen, but not why. Although much has been written on the theory of causation, it is sufficient to state, at least in this treatment, that the so-called cause is just a statement of the set of conditions which precedes or accompanies an effect.

Summary

Because of the limited scope of this paper, of necessity many details and issues have not been included. The principal concepts, conditions and procedures outlined for the idea formation phase of an investigation may be summarized as follows:

(1) An environment satisfactory for research—social, political, economic, and technological.

(2) An individual, or organization, interested and qualified for research and adequately sponsored.

(3) Sources of problems for research which act as "thought starters" and create an awareness of a subject to be investigated—an incitation.

(4) The selection and definition of a problem to be investigated.

(5) The concentration of the mental faculties of an investigator on the objective and scope of the problem until it is thoroughly understood and feasibility determined.

(6) The gathering of all information related to the problem by means of the literature and other surveys in anticipation of the disclosure of instances, hypotheses, theories, and methods which are suspected to be related to and suggest a solution of the problem. The information should be recorded on 3 × 5 cards and in a notebook.

(7) The sorting, rearranging and classification of the information as a basis for the determination of the known and unknown portions of the circumscribed area of the proposed research. See Fig. 1.

(8) In the case of the unknown areas and in tthe absence of any hypothesis, theory, or law suggestive of an experimental approach toward the objective, the synthesis of a "working hypothesis" the deductions from which may indicate an attractive path of high certainty toward a solution of the problem.

(9) The discriminate sorting and purposeful selection and classification of instances as a basis for reasoning. It will be helpful generally if these are arranged as in Fig. 2, thereby bringing more of the reasoner's faculties into action.

(10) The implanting of this conception —mental image, together with the objective sought, in the mind of the investigator for his reasoning powers to work upon. This is an "incubating" period.

(11) The elimination of all distractive influences or environmental factors, which, during reflective thinking, would prevent concentration on the purpose at hand.

(12) The period of "digestion" during which the conscious and subconscious mind is constantly and unrelentingly pressing for a simple formulation—hypothesis.

(13) Do not strain for a solution to the point of mental and physical exhaustion. When not making progress set the problem aside completely and allow the mind to wander and the investigator engage in a non-related, diverting, and pleasant activity stimulating to the imagination and emotions.

(14) After a period of rest and relaxation, the gradual emergence of an idea for a semitangible synthesis—to be written down—as an initial working hypothesis. Such ideas may emerge unexpectedly at any time, place, or under normal or unusual circumstances.

(15) Making deductions—written down —as in Fig. 2, and then an interplay between (1), (2), (3), and (4), but without losing sight of the purpose of the investigation. One of the inferences should indicate a solution to the problem. At times, the mind may by-pass this step and go directly to the solution of the problem.

(16) The design of experimental equipment and procedures to confirm inferences which indicate a solution of the problem or confirm the solution suggested in 15.

There can never be any guarantee that the faithful application of the foregoing procedures will lead to a successful solution of a problem. However, when through constant application, they become an integral part of the investigator's "working tools," they eliminate careless thinking and help to establish a basis for a possible solution. That is, the mind follows an operative technique which can be learned, applied, but always under control. We may learn the fundamentals of an art or procedure under competent guidance, but it is only through constant practice or application that a high degree of skill is attained. Therefore, the only path to success in research is the constant practice of research.

In a subsequent paper, a "flow-diagram" will be offered which will outline the various sequential steps usually followed from the conception of a problem to be investigated to its solution.

Suggested Collateral Reading

(1) "How we think." John Dewey. D. C. Heath & Company, N. Y., 1933.

(2) "Scientific Method." F. W. Westaway. Blackie & Son, London, 1924.

(3) "A Philosophy of Science." W. K. Werkmeister. Harper & Bros., N. Y., 1940.
(4) "The Basis and Structure of Knowledge." W. K. Werkmeister. Harper & Bros., N. Y., 1948.
(5) "An Introduction to Logic and Scientific Method." M. R. Cohen and E. Nagel. Harcourt, Brace & Co., 1936.
(6) "The Principles of Reasoning." D. S. Robinson. Appleton-Century-Crofts, 3rd Ed., N. Y., 1936.
(7) "Introduction to Reflective Thinking." By Columbia Associates in Philosophy. Houghton-Mifflin Co., 1923.
(8) "Philosophy, an Introduction." J. H. Randall and J. Buchler. Barnes & Noble, N. Y., 1942.
(9) "The Genius of Industrial Research." D. Killeffer. Reinhold Pub. Co., 1948.
(10) "The Path of Science." K. Mees. John Wiley & Sons, 1946.
(11) "The Art of Scientific Investigation." W. I. B. Beveridge. W. W. Norton & Co., N. Y.
(12) "The Way of an Investigator." W. B. Cannon. W. W. Norton & Co., N. Y., 1945.
(13) "The Scientist in Action." W. B. George. Emerson Books, Inc., N. Y., 1938.
(14) "How to Solve It." G. Polya. Princeton University Press, Princeton, N. J., 1948.

Industrial Engineering Summer School

A three day summer school sponsored by the Industrial Engineering Division of A.S.E.E. will be held at the University of Florida starting on Saturday, June 20. The theme for the conference will be "Quantitative Measures in Industrial Engineering Courses." The program is designed to acquaint the teachers with the recent developments in applying mathematical measures to all phases of the profession. Substantial progress has been made in the last two years, through the use of statistical mathematics, probability theory, linear programming, and similar techniques, which opens many new opportunities for research and development in motion and time study, production control, plant layout, cost control, process planning, etc. Instructors, who have been instrumental in this development work, will teach the several sessions. The program of the conference is as follows:

Saturday, June 20	1:30	Objective of the Program
	2:00	Motion Study
	3:30	Time Study
	7:30	Industrial Organization
Sunday, June 21	1:30	Plant Layout
	2:30	Materials Handling
	3:30	Manufacturing Costs
	7:30	Process Planning & Tool Design
Monday, June 22	8:30	Examination Fundamentals
	10:30	Project Method of Instruction
	1:30	Operations Research Approach
	4:00	Roundtable Discussion and Summary

The Summer School Committee consists of:

Howard P. Emerson
Grant Ireson
Robert H. Lehrer
Earl Martinson
Joseph Moder
Everett Laitala, *Chairman*

For further details address Professor Everett Laitala, Mechanical Engineering Department, Case Institute of Technology, Cleveland 6, Ohio.

The Electrical Engineering Curriculum—Present-Day Problems and Time Limitations

The following are condensations of papers presented at the first conference on Electrical Engineering held at the Annual Meeting at Michigan State College, June 25–29, 1951.

Mid-Century Trends in Electrical Engineering Curriculums

By R. G. KLOEFFLER

Head of Department of Electrical Engineering, Kansas State College

The analysis which is to follow covers the curriculums of 79 accredited colleges in electrical engineering. Seventy-four of these colleges offer a 4-year curriculum and the other five have adopted a 5-year period. The locations of the colleges range from Maine to California and from Minnesota to Texas, with stops at most of the points between. The schools included vary in size from the largest universities to some of the smaller state colleges. The analysis was based on the latest catalogues available and, except for a few cases, covered the 1950–51 curriculums. The aim in this analysis has been to get a cross-sectional picture of American college curriculums in electrical engineering at the mid-century.

The classification of subjects which is to be used in the data which follow will not meet the entire approval of any E.E. teacher. However, it may serve as a basis for comparison. In the preparation of this analysis, the author makes no claim for infallibility in the interpretation of subject matter covered by the description of courses given in college catalogues. All figures covering credit have been reduced to the semester-hour basis.

The analysis shown in the following table is largely self-explanatory. The reader should note that the figures shown in parenthesis are averages for the schools having a 5-year curriculum.

Reference to the totals given in the analysis under general education shows that at the mid-century the 4-year E.E. curriculums contain an average of 7 credit-hours in social science and 7.6 in the cultural sub-group. The average of the combined social and cultural sub-groups (general education) is 11.6 credit-hours. (The average of the combined sub-groups is not equal to the sum of the other averages since some schools may offer only social or only cultural subjects.) The combined average of 11.6 for the 91 per cent of all colleges which require subjects in general education indicates that we are requiring approximately one-half of the 24 credit-hours recommended by one of the committees of our Society. If we add the average number of credit-hours required in English language, 8.2, to the total for general education, we arrive at an average of approximately 20 credit-hours of work which is nontechnical in nature.

Conclusion

In conclusion, two trends have been shown by the foregoing analysis.

1. The introduction of options in the senior year of 4-year curriculums. For

the colleges covered by this analysis, 62 per cent still retain a single general curriculum. However, in at least 10 of these institutions, some specialization is available through the selection of electives by the student. In the 38 per cent of schools offering options, all offer an option in electric power and in communication and electronics. In addition to these options, there are a few scattered examples of op-

ANALYSIS OF 79 ELECTRICAL ENGINEERING CURRICULUMS
(74 4-year and 5 5-year)

	Credit range (1)	Average credit (2)	Number colleges offering (3)	Per cent (4)
I Mathematics				
(a) College algebra	2–5	3.2	43	58
(b) Trigonometry	1⅓–5	2.8	42	57
(c) Anal. geometry	2–6	3.8	66	90
(d) Calculus	4–20	8.3	71	96
(e) Diff. equations	2–6	3.0+	51	69
(f) Integrated math.	4–10	—	20	27
Total Mathematics	9–28	20.0(23.6)*	74	100
II Physical Science				
(a) Chemistry	4–12	8.0(9.8)*	74	100
(b) College physics	5⅔–20	11.0(13)*	74	100
III English Language				
(a) Composition	2–12	6.0(6.8)*	73	99
(b) Speech	1–4	2.2(3.4)*	43	58
(c) Tech. reports	1–6	2.3(3.3)*	28	38
Total English	0–14	8.2(13.5)*	74	—
IV Engg. Craftsmanship				
(a) Drawing & desc. geom.	2–10	5.5(6.8)*	74	100
(b) Shop	⅔–6	2.5(3.0)*	42	57
V Engg. Fundamentals				
(a) Applied mechanics	2⅔–7	5.1+(6.6)*	74	100
(b) Fluid mechanics (or Hydraulics)	2–5	3.0	45	61
(c) Thermodynamics	2–7	3.7	59	80
VI Technical Subjects				
(A) Electrical				
(1) Common subjects				
(a) Basic E.E. (electric circuits & magnetism)	2–10	4.9(5.5)*	72	97
(b) A-c circuit theory	2⅔–10⅔	5.8(9.5)*	73	99
(c) Elec. measurements	1⅓–6	2.8	43	58
(d) Basic electronics	2⅔–9	4.4(5.4)*	68	92
(e) D-c machinery	2–7	4.2(4.6)*	67	91
(2) Electric power group				
(a) A-c machinery	4–18	8.3(11)*	74	100
(b) Electronics (industrial, etc.)	2⅔–8	4.5(8.0)*	41	
(c) Transmission & distribution	2⅔–9⅓	4.0(5.0)*	38	
(d) Illumination	2–4	2.3(4.0)*	11	
(e) Transients	2–4	2.6	16	
(f) Design	⅔–8	3.3	22	
(g) Electives	2–13	7.4(6.0)*	22	
(h) Option	⅔–27	5.5(7.6)*	34	

* Five-year curriculums shown in parenthesis.

ANALYSIS OF 79 ELECTRICAL ENGINEERING CURRICULUMS—*Continued*

	Credit range (1)	Average credit (2)	Number colleges offering (3)	Per cent (4)
(3) Electronics & communication option				
(a) A-c machinery	4–16	6.9(7.3)*	42	
(b) Electronic circuits, etc.		4.5(9.1)*	21	
(c) Network theory	2–5	3.5(4.5)*	18	
(d) Communication (radio telephone, television)	4–15	8.8(9.1)*	39	
(e) Electromag. waves (UHF)	2–5	3.4	21	
(f) Option	2–27	5.0(10.4)*	28	
Total electronic & communication		23.4	35	
(B) Nonelectrical				
(a) Heat power engineering	1–8	3.7(5.2)*	57	77
(b) Mechanics of materials (Strength of materials)	2–8	4.4(5.9)*	73	99
(c) Metallurgy	2–3	2.4	6	8
(d) Surveying	1–5	2.5	40	54
(e) Engineering economics	2–9⅓	3.7+(7.4)*	27	37
VII Electives				
(a) General (free)	3–18	7.4	33	45
(b) Technical	3–16	7.5	34	46
(c) Nontechnical	3–15	6.5	24	33
VIII General Education				
(A) Social Science Group				
(a) Economics (general)	2–8	4.0(4.5)*	47	64
(b) Sociology	2–9	4.0	10	13
(c) History (industrial)		4.3	7	10
(d) Government	2–8	3.4	20	27
(e) Psychology	2–6	4.0	5	7
(f) Comprehensive	1–9	5.6	15	20
Total Social Science	2–21	7.0(12)*	64	87
(B) Cultural Group				
(a) Literature	1–6	4.2	17	23
(b) History	2–10	5.0	19	26
(c) Philosophy	⅔–6	4.0	3	4
(d) Civilization	1–16	7.2	12	16
(e) Comprehensive	3–12	6.1	10	13
(C) Electives		(9.0)*		
Total Cultural Group	1–22	7.6(17)*	41	55
Total Social Science & Cultural (Humanistics)	3–28	11.6(29)*	67	91
Total credit-hours	126–160	144(174)*	73	

* Five-year curriculums shown in parenthesis.

tions in business administration, illumination, industrial, and physics. One school lists a total of four options.

2. A secondary trend has been an increase in the humanistic-social content of the curriculum. This trend carries only half way to the goal set by our Committee on Engineering Education After the War.

Professional Education in Four Years

By EDWARD R. SCHATZ

Assistant Professor of Electrical Engineering and Industrial Administration, Carnegie Institute of Technology

Professional education in the broadest sense of the term is not a four-year matter. It is education that starts during the years of college (perhaps even before) and must continue for many years after graduation. It is education that must include a program of college training and an internship or apprenticeship in the years immediately following college where very often teacher and student are the same person. It is education that must continue throughout a career if that career is to be truly successful.

It certainly goes without saying that during the years of formal schooling, the college or university is directly in charge of guiding these educational activities, although it is equally clear that the responsibility for doing the learning is directly that of the student.

After college the direct responsibilities of continued professional education fall to the graduate and the industry that employs him. This placing of direct responsibility for continued learning after college is not meant in any way to absolve educational institutions of their responsibilities in the post-school period. In every activity of the young graduate, his college is vitally, if only indirectly, concerned. One of the responsibilities of an educational institution is to provide instruction and training during the formal schooling that will equip the student to make future learning effective no matter in what situation that learning may occur, be it learning from text book and professional magazines, or learning in the postgraduate course offered by his company, or, the most difficult to do well, learning through experience gained in dealing with others.

What can a college do during its very important but brief period of education to train a man to full professional competence? What can a college do to carry out its own responsibilities and to make the student realize and carry out his both during and after the college years? How long should the formal schooling process go on?

Instruction Aims

At Carnegie Tech we believe these questions are answered by a four-year plan of instruction with the following aims:

(1) A thorough understanding by each student of the nature and use of the fundamental knowledge in the fields covered by the student's profession, and the attainment by the student through his own efforts while in college of a set of values which may be used as a guide for thinking and action.

(2) A philosophical outlook and breadth of knowledge which will enable him to deal effectively with the social, economic and political problems of his professional life and his life as a citizen.

(3) The development of an orderly way of analytical thinking in the use of the fundamentals of all fields.

(4) The ability to learn for himself through experience and to make effective use of this learning in advancing his professional career.

A curriculum to carry out these aims can be divided into two classifications—the basic courses in both the physical and social sciences, and the technological courses.

In point of time at my school, the basic courses in the physical sciences occupy about one and one-half years of the four-year program; the technological courses—about one and one-half years; and the basic courses in the social sciences and the other courses in this area—about one year.

I feel sure this division of the time, the names of the courses and much of the subject matter covered are essentially the same as in many other technical schools, but success in the achievement of the main aims is found much more in how these courses are taught than in the particular curricular areas that have been covered. Each of these stems—the basic science and the technological—has as its reason for existence the carrying out of the four main objectives and herein lies the unity which I believe significantly characterizes professional education during the college years. The forces of education are not divided. Each curricular area is designed for training in fundamentals, for establishment and use of clear methods of analysis, for extension of knowledge and skills to other fields and for learning from experience.

Moreover, the functions of the various curricular areas can be made complementary. For instance, a particular class discussion in history concerning methods of historical analysis can help establish good analytical methods for a concurrent physics or mechanics course. A more complete description of such possibilities may be found in reference one (1).

One Direction Program

In this singleness of purpose, this unity, there is teaching strength. There is, in addition, another outcome of this teaching method. It is the economy of a program that is all pointed in one direction. There is no one in the wagon dragging his feet —no one teacher wasting the time of another. For example, there is no physics instructor tolerating poorly written work, thereby effectively teaching poor English and thus tearing down the efforts of the English Department. The result of this is an economy of time spent in reaching the stated objectives. The fact that great saving of time can be made in this way is one of the reasons why I believe adequate undergraduate education can be completed in four years.

How does one decide on what courses to put into a curriculum to carry out the above objectives, and what to put into the courses? It is not an easy matter to build such a curriculum by putting together various blocks of subject matter and then teaching that material by the methods described. There is a constant struggle between covering ground and using a minimum amount of subject material to amplify one of the objectives. There is, of necessity, a minimum content for each course, but this content should come as a result of planning and should not anticipate it. To design the curriculum and the courses in it, one should act as a teacher, not a subject-matter specialist. For example, the humanistic-social program at Carnegie occupies about one year of the four-year program and, as such, curriculum planning becomes a hopeless task if done from the point of view of total subject matter a student must master. The planning can only be undertaken without complete frustration if the planner remembers that the student has not one year to learn but a lifetime if he is trained properly. An example of course planning for freshman history may be found in the second reference (2).

Summary

Let me summarize the reasons I believe that this formal part of education should and can be a four-year program. In that time, the fundamental principles and knowledge necessary for continued learning in fields of interest to the engineer can be established and used professionally in many examples. The method of teaching described makes this possible in the four-year period. Secondly, there are sound reasons for getting a man into the post-school education period as soon as possible where he must accept sole responsibility for his learning, must make his start on a professional career, must apply in a real situation—and not a schoolroom experience—his knowledge and method of attack and, therefore, where he begins the most difficult task of learning of all—learning from experience. For the

average student I do not believe that this introduction to such learning should be unnecessarily postponed.

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Curriculum Size 5

[A somewhat condensed first portion of paper]

By E. E. DREESE

Chairman of Department of Electrical Engineering, The Ohio State University

I. *Introduction*

The hope for engineering education is that the educators are perennially dissatisfied. The curriculum is a hair shirt fashioned and refashioned, patched and repatched to fit a boy who has become a man.

II. *A Brief History*

Engineering curricula in this country had their origin in the general colleges in the middle of the 19th century—100 years ago. The philosophy of the arts college was early impressed upon the engineering teachers. At that time engineering education could be covered in one year.

Early in the 20th century the engineer became aware of his importance to our civilization and had a growing and embarrassing realization that he had little understanding, or interest even, in that civilization and its emerging social and human problems. The engineering journals of the times are replete with surveys, discussion, and reports on "culture" as it was called.

Between the world wars some of this "cultural" content came grudgingly back under the new name of "social-humanistic" studies but it was not until the 2nd world war that a committee of this society recommended that 20% of the student's educational time be devoted to these subjects.

In addition, the two world wars dramatized for the public and engineers alike that engineering science was growing exponentially—at the scientific roots—as distinguished from the foliage of mere gadgetry. This is probably no better illustrated than in electrical engineering itself. Prior to World War I there was only one fundamental within electrical engineering —circuits. After that war electronics became a basic electrical fundamental. Now after World War II a new fundamental has come into electrical engineering itself —field theory. Wave guides, resonators, radars, and antennas require this new fundamental. The rise of the various types of computers and servomechanism are increasing curricular pressures for extensions of the fundamentals in mathematics and circuitry.

Historically, too, there is the emerging sense of professionalism in engineering which envisions that the engineer be educationally equipped both in general and special education at a level compatible with professional status. Where should engineering fit in the scheme of professional education? It now requires 7 years for a first degree in medicine; 6 years for law; 6 years for veterinary medicine; pharmacy and optometry require 5 years. Four years are required for nurses and dental hygienists.

III. *The Post-war Dilemma*

In 1944 there were searching introspections by every institution of learning with committees working on curricula for a

changed post-war world. Engineering curricula were in particular trouble. There was compelling pressure to increase each of the three major portions of program—the social content, the fundamental content and the professional content. The descriptive courses of yesteryear were already gone. Improvisations and make-do shifts became the vogue. Mathematics was cut here—final examinations were dropped there. Paul was robbed to pay Peter. In general both fundamental and technical professional content were invaded in an attempt to reach the magic 20% for social content. Most have despaired while still short of that goal. The growing question still lingered—could the engineering schools keep faith with professional standards by turning out a product with even less professional engineering competence than they had hitherto? Was engineering to be some sort of low level profession?

IV. *The 5-year Solution*

After wrestling with these problems for months on end certain schools decided that the size 4 shirt was just too small for maturing engineering. It was realized that the 4-year concept was simply a tight fitting hand-me-down from our liberal arts forebears. Tradition, blindly accepted, becomes simply habit. Such thinking is necessary to gain freedom of mind.

As of today there are at least four schools with 5-year curricula for a bache-

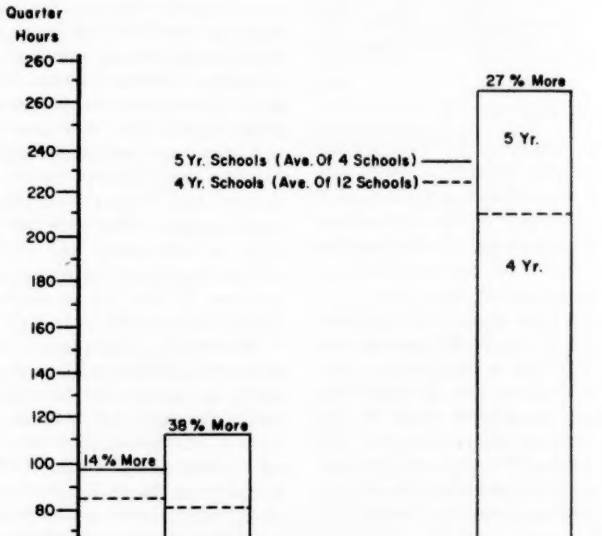

FIG. 1. Comparison of composite C.E., Ch.E., E.E., and M.E. curricula.

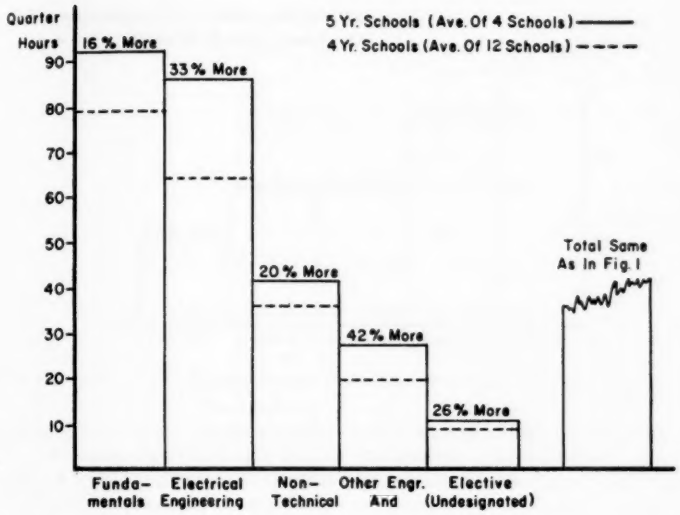

FIG. 2. Comparison of average electrical engineering curricula.

lor's degree in engineering. There are others with optional or variant programs.

V. *Curriculum Comparisons*

Before going into comparisons of existing 5-year and 4-year curricula we should be reminded that 5-year curricula have their individual differences just as do the 4-year curricula. Educational experimentation still goes on but those wearing the size 5 garment are not suffering the shortness of breath of those wearing size 4. No 5-year school claims its curriculum is perfect—it simply claims it is better, and timely.

In the following comparison charts an attempt is made first to eliminate individual differences in 5-year and also in 4-year curricula by comparing composite curricula of the two types. This is done for a group of curricula in Fig. 1 and for electrical curricula in Figs. 2 and 3.

A caution is necessary in interpreting this figure as well as the succeeding ones. The figures represent the comparison of present 5-year curricula and *present* 4-year curricula as revealed by latest available bulletins. The caution mentioned is against interpreting the 4-year values as though they were the *old* 4-year values of the present 5-year schools.

The term "fundamentals" here includes mathematics, physics, mechanics, chemistry and drawing.

The most significant difference is shown in technical content. This 38% difference is due only partly to the fact that 5-year schools increased technical content over their previous 4-year content. Probably the largest portion of this 38% is due to the diminution of technical content of 4-year schools to make room for increasing non-technical content.

The non-technical content of the 5-year curricula is 20+% of the total content of the average of the 4-year schools. This was the goal of the 5-year schools in agreement with the 1944 recommendation of the ASEE committee on "Engineering Education after the War."

In general, Fig. 1 shows that the 5-year engineering colleges have met the 20% of 4-years non-technical content and have maintained their objectives of giving a

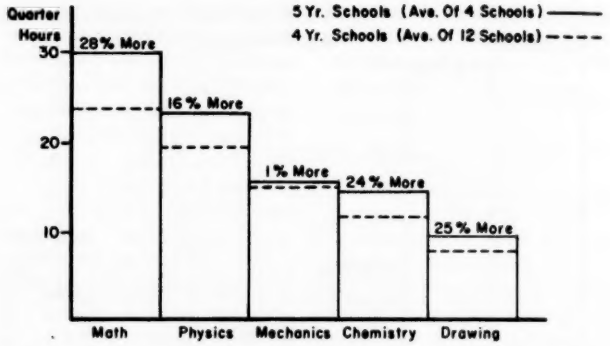

FIG. 3. Comparison of fundamentals in average electrical engineering curricula.

professional type technical education comparable to or better than they were doing previously. They have not invaded the fundamentals.

Fig. 2 compares the average (or composite) electrical curricula in four 5-year schools and in twelve 4-year schools. The figure shows that the comparison is roughly the same as for the composite engineering curricula in Fig. 1.

Here, too, the non-technical content is 20+% of prevailing 4-year content with 16% more fundamental content, 33% more electrical engineering content and 42% more other engineering content.

Figure 3 may be of interest in showing the comparison of fundamental content in the composite 5- and 4-year electrical engineering curricula. The greatest difference in fundamental content is in mathematics with 28% more in 5-year curricula. There are sizeable increases, too, in chemistry and drawing. There is practically no change in the mechanics content. This figure on mechanics may be an unavoidable error in interpreting college catalogs due to the varying pattern of the departmental location of mechanics courses in various institutions. It may be that in some institutions mechanics is "hidden" in the "other engineering" category.

VI. *Conclusion*

No school goes to 5 years lightly. It requires solemn soul searching. There comes a day and time when the task is too great to temporize with tradition and improvisations. That day is here—that time has come. It is the dawn of a new day.

TIMELY TIPS

Open-Book Examinations

By RALPH H. UPSON

Professor of Aeronautical Engineering, University of Minnesota

Professor Ross's interesting article in the October issue, "A Procedure for Teaching Fundamentals" presents, it would seem, some fundamentals themselves, not merely a procedure for teaching them. In this otherwise excellent article, it is somewhat bewildering at first sight to find the author advocating closed-book examinations, which have often been opposed for the very reasons cited by the author in their favor. To me, and I think to most engineering educators, the closed-book examination is rapidly becoming an outworn tool; but quite apparently, there is still room for discussion of the subject. Hence this appeal on behalf of open-book examinations for *all* engineering students.

Although it is realized that the positive approach is in most cases better than the negative one, it seems that in this case the merit of the natural, straightforward, open-book quiz or examination is most convincingly shown by pointing out the serious shortcomings of any arbitrary rule unnecessarily restricting the students' source material. Professor Ross's plea for teaching a student "to think by himself" is certainly a worthy objective on which there can be no dispute. I think it should be established at the outset, however, that encouraging a student to think by himself is possible with either type of test. Any reasonably competent and resourceful teacher with some practical engineering experience will be able to devise basic, thought provoking problems which will put the student on his own responsibility, regardless of whether the quiz is open or closed book. What then is the particular reason for banning consultation of books and notes directly? I see *no* reason for such a restriction beyond the static inertia of outworn custom, or to make the preparation and grading of examinations easier for overworked teachers. On the other hand, there are several very serious disadvantages, as follows:

1. The closed-book restriction is unrealistic. An engineer is *expected* to use books—for what they are worth, as aids to his own thinking, not as substitutes for it. If a quiz is properly designed, a student learns at the first trial that he cannot "bull" through by virtue of a pile of books and notes.

2. The same restriction makes memory work an unduly important function. It puts emphasis on the acquisition of information rather than on its use, and to that extent may actually discourage original thinking. Convenience and use are the only proper criteria for what is worth remembering.

3. Practice in the use of sound engineering resourcefulness is aided by every different source of information at the student's command. To deny him such a reasonable privilege as consulting his own notes and books, when most enlightened teachers now grant it, seems to him arbitrary, unreasonable and unfair.

4. As the average student sees it, the closed-book restriction penalizes the honest student in favor of the "successful" cheater. Intellectual honesty is so highly important in the engineering profession that *any* opposite influence should be

eliminated if at all possible. I have been the recipient of enough student opinion to be sure that this object is in fact greatly aided by the open-book privilege.

Instead of setting up unnecessary restrictions, how much better it would be, and how much more conducive of the student's cooperation and initiative, for the teacher himself to serve not as a proctor but as a consultant? Let him imagine that he is running an engineering office; the students are his staff, to whom he assigns engineering problems; then let him act accordingly and grant to each the use of all reasonable facilities, including his own cooperation!

In furtherance of the above mentioned analogy, some experiments have even been made in practical means of allowing consultation between students during an examination. The results, while interesting and indicative of possibilities, are not as yet thought conclusive enough to justify a definite stand on this particular issue.

One further point seems worth noting. Original thinking may be very *interesting* work, but according to accepted usage (psychological rather than mechanical) it is still work! And for the teacher to do any *less* thinking, and expect the students to do *more*, does not quite make sense. So, with examinations: on the positive side, they should be thought provoking, instructive *and* revealing. This goal sets up no royal road to a life of ease for the teacher; but it is a challenge to integrate quizzes and examinations into the general educational effectiveness of a modern engineering course.

Derivation of Formula for Right Triangles with Integral Sides

By W. E. HOWLAND

Professor of Sanitary Engineering, Purdue University

A derivation of the formula presented by F. C. Bragg for obtaining "Right Triangles with Integral Sides," in his recent article of that title in this journal may be of interest and of some value since one is more likely to recall a method than a formula.

Let the two legs of a right triangle be k and m and the hypotenuse be $k\text{-}m + n$. Then $k^2 + m^2 = k^2 + m^2 + n^2 - 2km + 2kn + - 2mn$. Therefore, $2km + 2mn = n^2 + 2kn$. Now, and for the remainder of this discussion, assume that n and k are whole numbers; then the right hand side of this equation is a whole number and the left also because it is equal to it. Consider now another right triangle similar to the first, but whose sides are each proportional to the corresponding sides of the first triangle in the ratio $(2k + 2n)$ to 1. The sides of this right triangle will then be $2k^2 + 2kn$ a whole number, $2km + 2mn$ equals $n^2 + 2kn$, a whole number, and $k(2k + 2n) - m(2k + 2m) + n (2k + 2n)$, a succession of whole numbers, equals $(2k^2 + 2kn) - (n^2 + 2kn) + (2kn + 2n^2) = 2k^2 + 2kn + n^2 -$ also a whole number.

By assuming the sides of the original triangle to be k, m, and $k + m - n$ and using similar methods, one may obtain the following somewhat different, but I think equally useful, formulas for the sides of a right angle triangle which are whole numbers when k and n are whole numbers: $(2k^2 - 2kn)$, $(2kn - n^2)$ and $(2k^2 - 2kn + n^2)$.

THE T-SQUARE PAGE

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DEVOTED TO THE INTERESTS
OF ENGINEERING DRAWING

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Let's Face the Music

By J. GERARDI

Chairman, Division Engineering Drawing

Those who have attended the recent meetings of the Drawing Division immediately recognize a perplexing atmosphere which seems to disturb our membership. Even the casual visitor discovers, before too long, that the drawing teachers are very much concerned about problems such as:

1. The misunderstanding which seems to exist between the engineers, educators and teachers as to the value of our present drawing courses in the engineering curricula.
2. The thoughts which have been expressed by some that drawing is of more importance to one branch of engineering than to another.
3. The problems concerning the amount of mathematics and other sciences which should be integrated into a course of graphics.
4. The assumption that drawing course contents have become static and that very few changes have been made within the past twenty-five years.
5. The impression which some of our friends in A.S.E.E. have that our drawing division feels that the world would come to an end if the slightest suggestion is made to de-emphasize lettering, use of instruments, geometric constructions, etc.

These and similar problems have had their fair share of discussion at our meeting and in all probability should be discussed further. But before we promote this activity, it might be wise to reflect for a moment on whether or not it is worthwhile.

At the convention last summer, Dean Hollister of Cornell University gave one of the most philosophical talks which has been presented before our Division. Although his slides were selected to emphasize the methods used by architects to develop originality and creative thinking, several in the audience were more interested in the lettering and line work which appeared on the slides. Others seem to have thought that this was an opportunity to get an answer to the problem concerning the decreased time allotted to the teaching of drawing. It was evident from the discussion which followed that the problems which were mentioned in the first part of this article are beginning to drown the best efforts of those who have a high regard for drawing courses and the Division's interests at heart.

The problems mentioned above must, of course, be resolved, but we cannot have them overshadow the more important projects which will enhance the prestige of the division.

As all of us know, the Engineers Council for Professional Development has asked A.S.E.E. to undertake an evaluation of engineering education. A committee with Dr. I. E. Grinter as chairman has been appointed to make the evaluation. The primary objective of this committee will be to determine why the basic pattern of engineering education has remained fixed and to determine whether new patterns of curricula are required to meet the rapid developments in science. One may hazard a guess that Dr. Grintef's report will not only have a profound influence on engineering curricula, but will also have a pronounced effect on the contents of technical courses.

Drawing Courses May Change Their Complexions

Drawing courses will be no exception. They too must be geared to the more recent advances in science and technology. Because of the short supply of engineers, the number of graduates who will begin their careers at the drafting board will decrease. Not only will they be expected to apply their knowledge of mathematics and science to engineering developments, but they may be expected to supervise the work of draftsmen. Hence, it may be predicted that drawing courses may of necessity change their complexions. No longer will the description of drawing courses in University bulletins list lettering, use of instruments, geometric constructions, etc., but may emphasize items such as—the study of shapes and form employing various materials to develop creative thinking, graphical solutions of engineering problems, supervision of draftsmen, etc. This change will not occur overnight, but we can expect something of this nature to develop in the near future.

Hence, let us "face the music," accept the challenge and direct our energies toward more efficient use of the time we have: let us revitalize our course content to such an extent that those whose courses have been curtailed may be given an opportunity to regain the necessary time to teach their courses properly.

The Drawing Division has served the A.S.E.E. for twenty-five years. Its activities and the resourcefulness of its members is well known. The many projects and studies which have been sponsored by the Division have been worthy of publication and have had a great influence in unifying course work with the demands of industry. No other Division of A.S.E.E. has a publication similar to the *Journal of Engineering Drawing*; moreover, our magazine enjoys world-wide circulation and has not shown a financial loss for the past fifteen years. These and other accomplishments of our Division are due to the initiative, loyalty and hard work of the men who founded and have led the Division.

In order to uphold the traditions of the past, and to encourage discussion, exchange of ideas, and active participation of our members, your officers this coming year, knowing that they can count on the excellent cooperation which has been given in the past, will initiate a program which will suggest a pattern of thinking along the following lines:

1. A critical review of the contents of present drawing courses and recommendations for the future.
2. A thorough study of the new requirements which the engineering profession will impose on graduates because of the short supply of engineers.
3. Divisional participation with Dr. Grinter's committee on evaluation of engineering education.
4. Methods of improving teaching and raising the level of instruction in graphics. Professor F. A. Heacock and his committee on advanced graphics has completed and published a report on "Graphical Methods for Solving Engineering Problems." This report will receive special attention.

The above suggestions are by no means fixed or final, and your chairman as well as your executive committee will welcome any suggestions which will improve the activities of the Division.

TEACHING POSITIONS AVAILABLE

The following rules were adopted by the General Council of the ASEE:

1. The privilege of advertising for teaching positions is extended only to colleges and technical institutes which are either Active or Affiliate Institutional Members of the ASEE.

2. Advertisements must be for positions available only. No advertisements will be accepted for an individual seeking a job.

3. Advertisements should not specify salaries.

4. Advertisements must be submitted not later than the first day of the month preceding the month of issue.

5. Because of limited staff, the ASEE headquarters cannot maintain personnel files or supply detailed information about jobs. In replying to blind ads, address letters to American Society for Engineering Education, Northwestern University, Evanston, Illinois and give blind ad number.

6. Information and rates for advertising in the Journal can be received by writing ASEE Headquarters.

INSTRUCTOR OR ASSISTANT PROfessor of Mechanical Engineering. Location upstate New York. Opening in either heat power or design. MR–1.

ASSISTANT OR ASSOCIATE PROFESsor of Electrical Engineering in upstate New York Technical College. Applicant should have ten to fifteen years experience in the fields of power and control, should have advanced degrees and research ability and interest. Can become key man upon retirement of present personnel in a few years. MR–2.

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INSTRUCTOR OR ASST. PROF. OF Manufacturing Processes to teach Metallurgy and casting processes. Opportunity for graduate study. Apply to Prof. Otis Benedict, Pratt Institute, Brooklyn 5, N. Y.

INSTRUCTOR OR ASSISTANT PROfessor in electrical engineering, primarily to teach circuits and machines. Send application to: Chairman, Department of Electrical Engineering, University of Denver, Denver 10, Colorado.

MASTER'S DEGREE IN ELECTRICAL engineering, and several years experience in communications and electronics as a teacher and in industry. Should be qualified to teach high frequency subjects. Appointment on twelve months basis requiring ten months attendance. MR–4.

INSTRUCTORS IN ENGINEERING drawing for September, 1953. Engineering graduates with some experience preferred. Nine months service. Summers free for industrial employment. Positions permanent with opportunity for advancement. Replies confidential. Write R. P. Hoelscher, 209 Transportation Bldg., University of Illinois, Urbana, Illinois.

CIVIL ENGINEERING ASST. OR ASsoc. Prof., structures and related subjects. Design experience and M.S. degree desired. A. & M. State College, Rocky Mtn. region, enrollment about 2000, opening June or Sept. MR–5.

POSITIONS OPEN TO TEACH DRAWing and mechanics, Dept. of Engineering Mechanics, University of Nebraska. Rank and salary based on applicants' qualifications. Write inquiries to E. J. Marmo, Chairman of Dept., Lincoln, Nebraska.

ASSOCIATE PROFESSOR ELECTRICAL Engineering: Duties; to instruct undergraduate students and develop post-graduate work. Time and facilities for research. Qualifications:—University graduate, preferably some post-graduate training. Several years practical experience which may include industrial graduate engineer training course—apply Nova Scotia Technical College, P. O. Box 1000, Halifax, Canada.

CONSTRUCTION ENGINEERING Teacher. Take charge of new mat'ls testing lab. & teach lect. & lab. courses in constr. practice. M.S. degree plus constr. exp. San Jose State College, San Jose, Calif.

MECHANICAL ENGINEERING Teacher. Take charge of new heat power lab. and teach lecture and lab. courses in M.E. M.S. degree plus industrial experience. San Jose State College, San Jose, Calif.

ENGINEERING DRAWING TEACHER. Take charge of drawing program including descriptive geometry and machine design. M.S. degree plus industrial experience. San Jose State College, San Jose, Calif.

POSITIONS STARTING SEPT. 1, 1953: Asst. Professor in C.E. (Soil Mechanics or Sanitary) and Asst. Professor in M.E. (Design and Production). Location—Calif. Master's degree, some experience required. MR–6.

CIVIL AND ELECTRICAL ENGINEERING teachers with doctor's degrees for research and teaching duties in southern university. MR–7.

POSITION OPEN FOR INSTRUCTOR in Engineering Drawing. Please address inquiries to Professor A. B. Wood, Head, Engineering Drawing Department, University of Tennessee, Knoxville, Tennessee.

POSITION OPEN FOR ASSISTANT Professor or Instructor in Industrial Engineering. Address inquiries to Professor H. P. Elmerson, Head, Industrial Engineering Department, University of Tennessee, Knoxville, Tennessee.

INSTRUCTORS IN CIVIL ENGINEERING—Excellent opportunity for part time research in highway engineering. Opportunity to pursue graduate work. S. R. Wright, Head, Civil Engineering Department, A. & M. College, College Station, Texas.

OPENINGS FOR INSTRUCTORS OR Assistant Professors. ChE to teach ChE subjects and Metallurgy; CE to teach surveying and allied work; and ME to teach Drawing and Descriptive Geometry. MR–8.

UNION COLLEGE, SCHENECTADY, New York, is seeking men with teaching and/or industrial experience for associate and full professorship in undergraduate Electrical Engineering and in Mechanical Engineering. Salary scale fair. Can be supplemented by evening graduate teaching and by good consulting fee from local industries. Apply to President Carter Davison.

ENGINEERING DRAFTING INSTRUCtor. We have an excellent opportunity for an instructor in a course which prepares students for direct placement in industry without further apprenticeship or on the job training. Applicants interested in this work should have had a minimum of several years teaching experience in mechanical drawing and a practical knowledge of industrial processes and procedures. Individual selected for this position will enjoy hospitalization, insurance, vacation, retirement and pension benefits. If you are interested please wire Mr. W. C. Porter, Chrysler Engineering Institute, Post Office Box 1118, Detroit 31, Michigan.

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny	West Virginia University	April 17–18, 1953	C. H. Cather, West Virginia University
Illinois-Indiana	Rose Polytechnic Institute	May, 16, 1953	H. A. Moench, Rose Polytechnic Institute
Kansas-Nebraska	Kansas State College		M. H. Barnard, University of Nebraska
Michigan	Detroit Institute of Technology	May 9, 1953	C. C. Winn, Detroit Institute of Technology
Middle Atlantic	University of Delaware	May 2, 1953	C. Bonilla, Columbia University
Missouri	Washington University	April 11, 1953	G. F. Branigan, University of Arkansas
National Capital Area	Howard University	May 9, 1953	L. K. Downing, Howard University
New England	University of Vermont	Oct. 10, 1953	E. T. Donovan, University of New Hampshire
North Midwest	Marquette University	Oct. 9–10, 1953	A. B. Drought, Marquette University
Ohio	University of Cincinnati	May 2, 1953	H. K. Justice, University of Cincinnati
Pacific Northwest	Washington State College	April 24–25, 1953	J. P. Spielman, Washington State College
Pacific Southwest	San Jose State College	Dec. 29–30, 1953	C. M. Duke, University of California at Los Angeles
Rocky Mountain	University of Colorado	April 11, 1953	C. A. Hutchinson, University of Colorado
*Southeastern	North Carolina State College		D. V. Terrell, University of Kentucky
Southwestern	University of New Mexico	April 3 & 4, 1953	M. L. Ray, University of Houston
Upper New York	Rochester Institute of Technology	October, 1953	F. E. Almstead, State University of New York

Members of the Society are welcome at all Section Meetings

* No Date Set.

New Members

ALSETH, HILDA J., Engineering Librarian and Assistant Professor of Library Science, University of Illinois, Urbana, Ill. H. H. Jordan, W. C. Huntington.

AMOS, CARROLL E., Associate Professor of Mathematics, University of Toledo, Toledo, Ohio. J. B. Brandeberry, W. Sherman Smith.

AUCK, DALE K., Director, Fire Protection Division, Federation of Mutual Fire Insurance Companies, 20 North Wacker Drive, Chicago 6, Illinois. A. B. Bronwell, W. R. Woolrich.

BACKER, GERALD H., Associate Professor of Aeronautical Engineering, University of Alabama, University, Ala. C. H. Bryan, W. K. Rey.

BADGER, IRVIN P., Assistant Professor of Civil Engineering, Ohio University, Athens, Ohio. E. H. Gaylord, E. J. Taylor.

BALL, BRYAN W., Instructor in Mechanical Engineering, University of Houston, Houston, Tex. W. B. Lowe, M. L. Ray.

BAUER, DAVID E., Assistant Professor of Industrial Engineering, Pennsylvania State College, State College, Pa. E. S. Roscoe, C. E. Bullinger.

BIBERSTEIN, FRANK A., Professor of Civil Engineering, Catholic University of America, Washington, D. C. J. W. C. Michalowicz, H. P. Gallogly.

BOSSENGA, JOHN R., Instructor in Engineering Drawing, Northwestern Technological Institute, Evanston, Illinois. M. B. Lagaard, R. Kliphardt.

BRISTOL, WALTER M., Director, Placement Bureau, State College of Washington, Pullman, Wash. H. Stern, A. B. Caseman.

BROWN, GEORGE M., Associate Professor of Chemical Engineering, Northwestern University, Evanston, Ill. R. Zinn, A. B. Bronwell.

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DELONG, HENRY H., Head, Agricultural Engineering Dept., South Dakota State College, Brookings, S. D. H. M. Crothers, W. Gamble.

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GLENN, GEORGE R., Instructor in Engineering Drawing, University of Louisville, Louisville, Ky. H. H. Fenwick, R. I. Fields.

GREGG, ROBERT, Lecturer in Industrial Engineering, University of Florida, Gainesville, Fla. J. Weil, E. P. Martinson.

GRIMM, CARL A., Instructor in Mathematics, South Dakota School of Mines, Rapid City, S. D. E. L. Swanson, E. E. Clark.

GROSS, WILLIAM A., Assistant Professor of T. & A. M., Iowa State College, Ames, Iowa. A. R. Livingston, H. J. Gilkey.

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HENDRICKSON, ELLWOOD R., Associate Professor of Civil Engineering, University of Florida, Gainesville, Fla. J. E. Kiker, T. L. Crawford.

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INGRAM, SYDNEY B., Director of Education and Training, Bell Telephone Labs., New York, N. Y. F. D. Leamer, R. A. Deller.

JENKS, RICHARD E., Employment Assistant, Socony-Vacuum Oil Co., Inc., New York, N. Y. P. W. Boynton, K. B. Korsmeyer.

JOUPPI, ARVID F., Staff Member, Educational Relations Activity, Public Relations Dept., General Motors Corporation, Detroit, Mich. K. A. Meade, R. L. McWilliams.

KALE, ETHEL L., Librarian, College of Engineering, Duke University, Durham, N. C. C. R. Vail, E. K. Kraybill.

KITTINGER, WILLIAM T., Assistant Professor of General Engineering, University of Houston, Houston, Tex. W. J. Leach, C. V. Kirkpatrick.

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KOGA, ISSAC, Professor of Electrical Communications, Tokyo University, Bunkyo-ku, Tokyo, Japan. A. B. Bronwell, H. L. Hazen.

KUBE, WAYNE R., Assistant Professor of Chemical Engineering, University of North Dakota, Grand Forks, N. D. D. E. Severson, A. M. Cooley.

LEWIS, CHARLES H., Instructor in Mathematics, Orange Coast College, Costa Mesa, Calif. J. B. Franzini, B. M. Green.

LING, DANIEL S., Associate Professor of Civil Engineering, Wayne University, Detroit, Mich. D. Newton, R. H. Zumstein.

MACFARLAND, HOWARD T., Instructor in Electrical Engineering, Lehigh University, Bethlehem, Pa. J. J. Karakash, L. V. Bewley.

MCFARLIN, ROBERT J., Instructor in Engineering Drawing, University of North Dakota, Grand Forks, N. D. E. V. Wenner, E. L. Lium.

MCGINLEY, JAMES G., Instructor in Applied Mechanics, Virginia Polytechnic Institute, Blacksburg, Va. D. H. Pletta, J. W. Whittemore.

MEHRHOFF, JOSEPH C., Instructor in Civil Engineering, Louisiana State University, Baton Rouge, La. T. M. Lowe, F. F. Pillet.

MILLER, ROBERT F., Acting Head, Physical Sciences, Milwaukee School of Engineering, Milwaukee, Wis. F. J. Van Zeeland, F. Kaufmann.

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NORRIS, FRANK F., Instructor in Architectural Engineering, University of New Mexico, Albuquerque, N. M. W. R. Gafford, J. J. Heimerich.

NORRIS, WILLIAM E., Assistant Professor of Electrical Engineering and Mathematics, USN Postgraduate School, Monterey, Calif. F. E. LaCauza, R. K. Houston.

OWEN, CHARLES V., Instructor in Civil Engineering, University of Arkansas, Fayetteville, Ark. L. R. Heiple, J. R. Bissett.

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PAYNE, WILLIAM H., JR., Head of the Department of Manual Arts, Div. 2, Public Schools of the District of Columbia, Washington, D. C. L. K. Downing, E. R. Welch.

PETRACH, ROBERT V., Instructor in Industrial Com., Milwaukee School of Engineering, Milwaukee, Wis. F. J. Van Zeeland, F. Kaufmann.

PRESSBURG, BERNARD S., Associate Professor of Chemical Engineering, Louisiana State University, Baton Rouge, La. J. Coates, L. J. Lassalle.

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ROTHFUS, ROBERT R., Associate Professor of Chemical Engineering, Carnegie Institute of Technology, Pittsburgh, Pa. C. C. Monrad, L. M. Canjar.

RYERSON, FRANK E., JR., Instructor in Engineering English, University of Louisville, Louisville, Ky. R. C. Ernst, G. C. Williams.

SCHOEFFLER, ALFRED W., Assistant Professor of Civil Engineering, Southwestern Louisiana Institute, Lafayette, La. F. Harding, H. M. Morris, Jr.

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STEVENS, EDWARD H., Associate Professor of Geological Engineering, South Dakota School of Mines, Rapid City, S. D. E. D. Dake, W. E. Wilson.

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WHITCOMB, RICHARD N., Mgr., Tech. College Recruiting, Goodyear Tire and Rubber Co., Cuyahoga Falls, Ohio. D. Thomas, T. W. Prior.

WILLIAMS, MELVIN C., Assistant to the Dean of Engineering and Instructor in Civil Engineering, Louisiana State University, Baton Rouge, La. L. J. Lassalle, F. F. Pillet.

WILSON, J. S., Personnel Manager, Corn Products Refining Company, Argo, Ill. A. B. Bronwell, W. R. Woolrich.

WIRTZ, LEO A., Instructor in Electrical Engineering, Kansas State College, Manhattan, Kans. R. M. Kerchner, E. L. Sitz.

WOLFE, J. EDMOND, Associate Professor of Electrical Engineering, Kansas State College, Manhattan, Kans. R. M. Kirchner, R. S. Kloeffler.

403 new members elected this year

The Professional Engineer—

Ascending to New Heights or Leveling Off to Mediocrity?

By W. R. WOOLRICH

President of the American Society for Engineering Education and Dean of Engineering, University of Texas

For more than four decades the Founder and associated engineering societies have been making some effort to bring together all of the professional engineers of the United States as a unified group. Their problem is not unlike that which faced the Continental Congress when that body labored with the task of bringing together the people of thirteen states each with a high premium on their political freedom.

The first organizational attempt to unify the engineering professions was initiated in 1920 by the Founder societies when a Federation of American Engineering Societies was formed with the American Engineering Council as its operational staff. By 1924 this organization structure was changed and then evolved the American Engineering Council as a single unifying agency.

The early activity and progress of the American Engineering Council was effective from its point of vantage in Washington, D. C. but its financial structure was not one that could withstand the vicissitudes of a sustained depression. Dissention about both the function and financial support of this Council led to its complete abandonment by 1938, another depression fatality.

Growth of ECPD, NSPE, EJC

While the American Engineering Council was experiencing a loss of national society moral and financial support, there was organized in 1932 the Engineers' Council for Professional Development dedicated to promote the professional growth and status of engineers and potential candidates of engineering from the period of pre-college preparation thence through college and pre-registration to final recognition as a member of the profession.

During this same period of the rise of the ECPD, an active segment of the professional engineers registered in the several states founded the National Society of Professional Engineers in 1934 and established headquarters in Washington, D. C. Full membership in this organization was limited to those who were recognized by state registration as professional engineers. Many of the services performed by the American Engineering Council for the engineering profession at the national capital were taken up by the NSPE as the ACE closed its doors in 1938.

In 1941, the several Boards of Directors of the Founder Societies created a Joint Conference Committee made up primarily of their retiring Presidents and Executive Secretaries. This group after four years of deliberations established, with the approval of their respective Boards, the Engineers' Joint Council.

It was this Council together with the National Society of Professional Engineers that in July, 1952, secured the Congressional recognition of engineering as a profession in a directive which Congress gave to the Salary Stabilization Board of the United States. This statute exempted professional engineers employed in a professional capacity from further wage and salary controls on the same basis as members of the medical and legal professions.

Unionization of Engineering

This recognition immediately brought forth a stepped-up activity of the independent bargaining engineering unions. Any permanent legislation by Congress which would recognize engineering as a profession would curtail the field of activity of engineering collective bargaining agencies.

Their published reports show that on December 31, 1952, the independent bargaining groups of engineering employees as independent unions were activated as The Engineers and Scientists of America (ESA). It was their hope that by the time of their first annual meeting in Los Angeles in February of 1953, the forty thousand members of the local groups would unite into one national organization, the ESA. The interim President, Mr. Joseph Amann, announced: "Representatives of Engineers and Scientists of America are prepared to meet other labor leaders and Senator Taft to discuss amendments to the Taft-Hartley Act, provided a meeting can be arranged. Engineers and Scientists of America is the only national organization whose members engage in collective bargaining with their employers to speak for the approximately 400,000 employed non-supervisory professional engineers and scientists who are so vital to our national defense and to our way of life."

The Vice-President of the newly formed ESA, Mr. John Taft, at an open meeting at Summit, N. J., November 19, 1952, outlined the activities through which they expect to carry on their promotion. The first activity mentioned was announced as "Representation of engineering and scientific employees before government bodies, colleges, political groups, etc. for the purpose of 'setting things straight' with regard to engineer's views on matters of interest to them."

Following his formal talk at Summit, Mr. Taft stated: "ESA expects to conduct an 'Industry Evaluation' program in which it will study the working conditions, salaries, fringe benefits, etc. of various large firms. The result of the study will be made available to college students as well as to the engineering and the scientific profession for their information and guidance." He further revealed that ESA plans to organize student chapters at major engineering colleges and defended this plan by stating that professional societies have student chapters and that his organization is entitled to the same prerogative.

The previous surveys of the National Societies Committee prepared in May, 1946 indicated that as of that date less than five per cent of the engineers questioned favored a certified union. Those who opposed the union of engineers did so usually on the basis that by unionizing:

1. Individual initiative would be restricted.
2. Individuals would be regimented by the union organization.
3. A "typing" of engineering positions and a "leveling" of salaries would result.
4. Professional status and prestige of engineers would be damaged if not lost entirely.
5. Individual advancement and recognition of individual achievements would be stifled.

Probably our democratic process of our unifying engineering councils has been too slow to keep pace with the rapid strides made by the engineering profession. The Engineers' Joint Council, the Engineers' Council for Professional Development and the National Society of Professional Engineers now face the alternative of speeding up their coordinated effort to improve the professional status of the recognized engineer or giving way to a less discriminating group of union engineers who would like to speak for all of us on the workman's side of the collective bargaining conference table.

Responsibility of American Industry

American industry has also much at stake in this situation and much of the corrective work in our present salary scales must come from the employers of engineers. There is little about which to

quarrel by the engineering profession as related to beginning salaries for men with Bachelor's, Master's or Ph. D. degrees in engineering, but the scales of advancement have been woefully neglected by a large portion of American industry. If management would do its part, the spread in salaries for professional engineers must be greatly increased for men of three, five, ten or twenty years of service commensurate with the beginning salaries if the engineering unions are to be effectively answered.

The engineers of less than average ability can generally be given a salary lift by a collective bargaining agreement. In the leveling off process he gains at the expense of those who are above the average. When a union is first established there may be even a higher average wage than could have been obtained by individual contract by superior engineers. But the future is not too bright in collective bargaining for the advancement of men of creative genius and individual professional abilities. Collective bargaining is never inspirational to the man of creative talents and recognition cannot be readily afforded him other than as part of a collective group.

Role of the Engineering Societies

In this emergency may we look to the Engineers' Joint Council, the National Society of Professional Engineers and the Engineers' Council for Professional Development to effect a program for the elevation of the professional engineer to new heights of accomplishment. We urge that American industry follow the leadership of some of the associated member companies of the American Society for Engineering Education and revise their salary scales for the advancement and recognition of engineers to levels commensurate with their professional contributions.

More recently, the Engineers' Joint Council has greatly broadened its base of membership to offer participation by a selected group of additional professional engineering societies. The American Society for Engineering Education has accepted membership within this Council. Past President Thorndike Saville is the appointed representative of the American Society for Engineering Education and in the reorganization of EJC at the session of January 24, Dean Saville was named its Vice-Chairman. He is our spokesman in this expanded program.

The future of engineering as a profession in North America depends upon the ability of the engineering colleges to advance their education to new levels of professional achievement. The incentive for both students of engineering and the engineering colleges, however, is in the hands of those who direct the progress of the graduates after they leave the college halls.

The answer to either the students of the engineering colleges or to the man who plans to grow is not unionism. The reward for which the professional engineer strives is a composite of full recognition and appreciation for the manpower product of the engineering colleges by those who employ, advise and direct. The compensation should be commensurate with the abilities and contributions of each individual of the profession. It is essential that the salaries for men of accomplishment and years of service shall be an incentive to the men entering the profession.

We need, now, positive constructive action in this emergency by our constituted leadership of the engineering profession. The evolving Constitution of our unity organization does not authorize autocratic action so essential in emergencies to the preservation of our national government but we must face this problem of *unionism* vs. *full recognition as professional engineers* before the eyes of all Americans with decisiveness and constructive action. It will require an all-togetherness and unanimity of purposefulness to meet the rising trend to legalized mediocrity through collective bargaining. If we, as professional engineers, are as effective in applying the principles of management as we boast, then our unity organization can find the answer without our turning to dictatorial government agencies for a solution.

Do You Know That—

► The program for the Annual Meeting —University of Florida, June 22–26— strongly emphasizes the influence which the rapid advances in science and technology are exerting upon engineering education. The Councils, Divisions, and Committees have diligently planned conferences and General Sessions to bring to the membership some of the nation's foremost authorities on the vital problems affecting engineering education. We are anxious to tell you all about it, but it would take half of this issue of the *Journal*. So here's a once-over-lightly synopsis of some one hundred and fifty papers which will appear on the program.

► A challenging General Session featuring nationally eminent speakers on "Encouragement of Fundamental Research as an Aid to Education in Engineering" has been arranged by the Research Council for Wednesday morning. The ECRC program will also include a conference on research developments in the South, and another on the ever knotty problems of Contract Relations with the Government, in addition to its traditional Banquet on Tuesday evening.

► Our Administrative Council (ECAC) is planning a timely General Session dealing with relationships between education and the engineering profession. This will also include some interesting developments in the articulation of high school and college studies, a current problem being developed by the Committee on Secondary Schools.

► Invitations to attend the Annual Meeting are being extended to engineering colleges throughout the world (except for Malenkov's proletariat). In addition to the International Night Dinner, which has become a distinctive event at the Annual Meeting, the International Relations Committee of ECAC is planning a conference program, featuring a number of speakers who are shaping the government's program of technical assistance to foreign countries.

► Mathematicians and engineers alike will be interested in the two conferences on "Programing for Electronic Digital Computers" by Dr. J. H. Curtiss, Chief of the National Applied Mathematics Laboratories of the Bureau of Standards. This is an unusual opportunity to enlarge upon our knowledge of this development which is revolutionizing higher mathematics and engineering. Several of the other mathematics conference papers have the intriguing titles "Let the Pythagoras Do It" and "The Mental Constructs of Science."

► A repeat on last year's successful conferences on atomic energy will be staged again this year, with outstanding atomic energy authorities.

► Here is a unique opportunity to organize a prospecting party and make your trip profitable! Mineral Engineering is scheduling a paper on "Oil Possibilities in the Southeast," by a noted Florida state geologist who should know. We hope that he'll drop a few hot tips.

► Engineers and economists will be interested in the outstanding program of the Engineering Economy Division, featuring a number of prominent economists from industry.

► Civil Engineering, as usual, has come through with an outstanding and varied program. One conference will deal with "The Place of the Doctor's degree in Civil Engineering," another with "Transportation Engineering," and still others on

"The Integration of Graduate Work by Means of Analogues." The Fluid Mechanics advocates will have their conferences dealing with Instrumentation, Sanitary Engineering, and Hydraulics. Also, there is an interesting conference entitled "Professional Skills as Tools in Developing Initiative and Originality," sponsored jointly by the Civil Engineering and Educational Methods Divisions. The Civil Engineering and Architectural Divisions are scheduling a conference on the Training of Engineers for the Construction Industry.

► Chemical Engineering will feature the teaching of instrumentation in Chemical Engineering, with a distinguished panel of speakers.

► The Electrical Engineering Division is planning a unique series of open-forum discussions relating to various areas of electrical engineering instruction, designed to identify some of the more acute problems in this field and discuss new trends and subject matter integration.

► The Educational Methods Division is doing an active and very effective job in intra-curricular coordination, as well as in investigating vital areas of teaching improvement. This is reflected in unusual conference titles such as "Developing Originality in Terms of New Tools of Engineering," "Educational Research," "Subject Matter Integration," "Professional Skills as Tools in Developing Initiative and Originality."

► Engineering Mechanics has several unusual conferences devoted to "Objectives in Advance Design," "Presentation of Undergraduate Mechanics" and a luncheon talk on Engineering Leadership.

► Engineering Drawing can always be counted on for stimulating and educational programs and this year's conferences on widely varying subjects will be of vital interest and a real challenge to drawing teachers.

► In addition to several joint conferences with the Divisions of Engineering Drawing and Civil Engineering, the Architectural Engineering Division is planning a discussion centered around "Architectural Engineering Curricula" at various universities.

► The energetic and rapidly growing Relations with Industry Division has top-flight conferences centered around the themes "The Impact of Recent Industrial Trends on the Engineering Profession," "Education-Industry Cooperation for Promoting Pre-College Preparation," and "Education-Industry Cooperation on Faculty Employment in Industry." These conferences will be of great interest to our members from industry, as well as to educators.

► The Humanistic-Social Division and English Division have formulated interesting programs dealing with "The Challenge of the Creative," "Meeting the Practical Problems," "New Directions in the Humanistic-Social Program," and one with the provocative title "How Can the Humanistic-Social Studies Contribute to the Professional Development of the Engineer?"

► For a refresher, try this one of the Evening Engineering and Graduate Studies Divisions—"Graduate School Traditions, Are They Adequate For Expanding Nation-Wide Programs in Graduate Engineering Education?" We hope that they get an answer to this vexing problem which confronts many engineering colleges.

► The Graduate Studies Division also has a conference program on "The National Science Foundation and its Relation to Engineering Colleges."

► Industrial Engineering is featuring conferences on "Quantative Measures in Industrial Engineering," "Industrial Engineering Practices in Industry" and "Materials Handling."

► A distinctive feature started last year was a conference by the Engineering Li-

braries Committee which has been widely acclaimed by technical journals throughout the country. This year's conference will again deal with engineering literature and its importance in engineering education.

► All young engineering teachers will want to attend the eventful and imaginative program consisting of three conferences, a luncheon, and a dinner, arranged by the ASEE Committee on Young Engineering Teachers. The prize winning papers for the Young Engineering Teachers' Contest will be presented on Tuesday afternoon, along with several papers, one having the intriguing title, "The Young Engineering Teacher—His Responsibilities and Frustrations." Another of their conference papers is entitled, "The Second Look—Or a Double Take" and still another has a live demonstration entitled "Reflections" by an anonymous performer.

► Technical Institute teachers are assured of an exceptionally informative program dealing with some of their more acute problems in the conferences dealing with "Technical Institute Relations with the Public," "The Role of Technical Institute Education in the Years Ahead," and numerous other highly pertinent subjects.

► The Cooperative Education Division will hold a clinic to dissect current problems in cooperative education, as well as a conference on Observations of the Cooperative System of Education.

► Crystal-gazing is the distinctive feature of the Aeronautical Division in its unusual conference "The Aeronautical Curriculum of Tomorrow."

► Mechanical Engineering offers an interesting and varied program including a conference on "What is Our Job in Heat Power-Education or Research?" One of the papers has the alluring title "So You Want to be Promoted." Interesting programs are also planned by the Machine Design and Manufacturing Processes Committee and the Division will have a dinner to top off the program.

► The General Session on Tuesday morning will feature talks by Dr. Hillis Miller, President of the University of Florida, and our own President Woolrich, as well as another speaker of national prominence. A unique feature this year will be a General Session on Monday afternoon, at which time there will be an open-forum discussion on some of the principal projects of the Society, including the work of the Committees on Evaluation of Engineering Education, Teaching Aids, Promotion of Ethical Standards, and Engineering Manpower. This will provide an opportunity for the membership to express their ideas on some of the principal Society projects.

► The Banquet will again be on Thursday evening, at which time there will be a noted speaker and the Lamme and George Westinghouse Awards will be presented to recipients. A new feature this year will be the presentation of two awards for the prize-winning papers by young engineering teachers—an innovation which has proven exceedingly popular with the younger members of the Society.

► The University of Florida Local Committee has done a superb job in planning general entertainment for Wednesday evening and an irresistible program for the ladies, including visits to many of the entrancing vacation attractions of Florida, and even sitter service and entertainment for the kiddies.

► Here is an unusual opportunity to expand your outlook on engineering education, enhance your professional values, make new and stimulating contacts, and to combine all of this with a good time. Why not mark it on your calendar now —June 22–26, University of Florida.

► See you in Florida.

ARTHUR BRONWELL
Secretary

The University of Florida

For many who come to Florida in June, 1953 to attend the Annual Meeting of the American Society of Engineering Education it will mean revisiting a State where they have found many delightful days of vacationing at other times. It likewise will mean a surprising satisfaction to all to find a spirit of economic importance, developed out of industrial and agricultural growth.

The University of Florida takes pride in the knowledge that it has made and continues to make valuable contributions to that growth.

The University is happy that the American Society of Engineering Education has seen fit to hold its Sixty-First Annual Meeting in connection with the Centennial Celebration of its founding.

The beginnings of the University go back one hundred years, back to days when its first College of Arts and Sciences opened in 1853. With the passage of the Morrill Act, the College of Agriculture, College of Engineering, and the Agricultural Experiment Station came into being.

It is a matter of special interest to educators that as far back as 1905, the State Legislature wisely abolished the then existing six State Colleges and provided for two new institutions of which the University of Florida is one. This Act of the Legislature provided for a Board of Control composed of seven members representing the seven geographical sections of the State, all serving without compensation except for travel and incidental expenses, and gave to this Board supervision over the two newly created institutions.

This simplified program of operation of the two institutions of higher learning has meant much to the State and to the University. Some years ago a move made by the University was the adoption of lower and upper division categories for undergraduate education. Under this program the student is given basic comprehensive courses and essential background courses for the specialized fields during the first two years. The junior and senior years are devoted to studies in the several specialized colleges.

There has been the closest cooperation among the lower and upper divisions, resulting in a smoothly functioning program and enabling the student to qualify fully and promptly for his chosen specialized field.

The home of the University of Florida is Gainesville, a city of not more than 30,000 in population situated in the rolling highlands of Central Florida about midway between the Atlantic Ocean and the Gulf of Mexico. Extremes of heat are unknown and frost rarely occurs, and these favorable conditions, together with relatively slight variations in humidity, insure an equable climate ideally suited for study, recreation and rehabilitation.

While the State of Florida is often thought of as a winter resort and playground, the citizens of the State, many years ago, realized the need of developing the many natural resources found here and thus began the move of industry into the State keeping step with the rapid development of agriculture and cattle raising.

The College of Engineering of the University was quick to appreciate the need for trained engineers to meet the rapidly growing requirements of industry. Since the early forties the entire staff of the College has grown from 24 to one of 240 inclusive of the personnel assigned to the Engineering and Industrial Experiment Station. During that same period, the research work done in the College has proved of highest importance to the Defense Program of our country. Much of

this work is still top secret but it can be told that the contribution made to the development of the VT proximity fuze and the work on storm location, later called sferics, earned national and international recognition for the College.

Early in 1951 the first wing of the new building designed to house the College of Engineering was dedicated. In it are now housed the administrative offices, the engineering sciences library and some of the facilities required by the Electrical, Mechanical, Industrial and Civil Engineering Departments consisting of offices, class rooms and laboratories. When entirely completed, the building will have a floor space of more than 250,000 square feet.

The Engineering and Industrial Experiment Station came into actual being in 1941 as an integral part of the College of Engineering. By this act, the State Legislature gave clear recognition to the fact that a program of research is essential as a complement of a great educational program and established the College of Engineering in the upper bracket of outstanding Engineering Colleges in America.

Mention of a partial list of the research projects undertaken by the College will show the spirit of the College in promoting the welfare of the Nation and the development of the resources of the State, such as pulp and paper technology, sewage and waste disposal, fluorine technology, tropical deterioration, ceramics, electronics and weather radar research.

Bachelor's and Master's Degrees are granted in Aeronautical, Agricultural, Chemical, Civil, Electrical, Industrial and Mechanical Engineering. All curricula, except the Agricultural (which is new), are fully accredited by the Engineering Council for Professional Development.

The Doctor's Degree is given in Chemical and Electrical Engineering and the Degree of Professional Engineer is offered in each degree granting department.

Since 1941, there has been a steady increase in the student body of the University which reached a peak of approximately 10,000. The College of Engineering enjoyed a similar increase with a maximum of about 1800. Contrary to the trend which showed a decrease on a national scale as indicated by a Government survey made in 1951, there were twice as many Freshmen engineers at the University of Florida in 1951 as compared to the enrollment of 1941. The current Freshmen engineering registration has increased to about 650 which is about 200% above the 1941 enrollment.

Likewise, the teaching and research staffs have grown. At present the College has a total professional staff numbering 123, of whom there are 27 who have received the Doctorate Degree.

The College budget also has expanded and the combined teaching and station budget is now $1,500,000. The station budget is about $1,000,000 which is twice that of the teaching budget. About $180,000 of this amount is appropriated directly to the station from state funds, the remaining coming from contractural sources.

The College early realized the importance of working with industry and engineers in the field. This is evidenced by the establishment in 1922 of a "short course" for those interested in electric measurements. It is probably one of the oldest University "short course" conferences in the country. Since that time, similar conferences have been held in the fields of Highways, Public Health, Surveying and Mapping, Air-Conditioning, Industrial Instrumentation, Pulp and Paper Technology and other fields of interest.

The State has provided an attractive retirement program for its employees, provided for pleasant working conditions and maximum academic freedom for all.

Proper dissemination of research for the benefit of other workers in the field and for the public in general is of paramount importance. No matter how significant the research results may be, the value of the research may be lost unless the information is put in the hands of those who can use it. Thus, it is the aim of the College to publish all research of

value conducted by the Experiment Station except where national security is involved.

There are three series of Station publications: (1) Bulletin Series—original publications of research, usually on problems of specific interest to the industries of the State of Florida; (2) Technical Paper Series—reprints of technical articles by staff members appearing in national scientific publications; and (3) Leaflet Series—non-technical articles by staff members which have appeared in the more popular periodicals. These papers are published under the title "ENGINEERING PROGRESS at the University of Florida" each month. In addition to a regular subscriber list of 1200, publications are circulated to some 6000 to 7000 individuals each year by special written request.

Since the publication of its first bulletin in 1933, the Station's list of publications reporting results of research completed or in progress has grown to 170. In addition, many restricted reports have been issued to industrial and military sponsors of Station projects.

Thus the College of Engineering, through the Experiment Station, continues to fulfill its purpose of conducting "research in the field of engineering and related sciences with special reference to such of these problems as are important to the development of industries in Florida" and to promote the graduate program in engineering to supply those industries with trained personnel.

Reserve this date . . . .

June 22-26, 1953

ANNUAL MEETING

UNIVERSITY OF FLORIDA

GAINESVILLE, FLORIDA

An Experiment in Conference Teaching

By HERBERT L. MANNING

Head, Department of Industrial Engineering, Virginia Polytechnic Institute

This experiment in the conference method of instruction is the result of discussions with a number of recent graduates of the Industrial Engineering Department at Virginia Polytechnic Institute. In these discussions one outstanding omission has come to light in our curriculum. Returning graduates have stated repeatedly that they are not prepared when they graduate to participate in or to lead group discussions. The conference method is used by industry extensively in the training of the men we graduate and also to train others of their supervisory personnel for management staffs. An analysis of our curriculum discloses the usual situation:

1. The program is already overcrowded.
2. Nothing appeared possible of elimination so that course material could be added to assist the program.
3. All students are required to take a course in "public speaking."
4. The problem would not be solved by more course work of the type usually thought of as "public speaking."
5. One course was available which included conference leadership as a technique of supervisory training.

The next point was to analyze our teaching methods in the department to see whether any changes could be made which would yield the desired results. It was decided to experiment on three courses in which substantial amounts of practice might be obtained by the students in conference participation and conference leadership. These three courses are "Principles of Industrial Organization and Management," "Wage and Salary Administration," and "Industrial Supervision."

In order to accomplish the mission in the management course it had to be redesigned and material of a case study nature accumulated which would illustrate the principles of industrial organization and serve as a basis for discussion. This course is taken by the Industrial Engineering students during the junior year and there was some hesitation in attempting to teach by the case study method at such an early stage. It was felt that one of the major objectives in this program should be the establishment of self confidence in the student's ability to lead and actively participate in group discussions. Therefore, starting the experiment in the junior year gives the students as much practice as possible before their graduation. Accordingly, the work was outlined for the first quarter course so that the instructor led the discussions for about the first four weeks of the quarter. During this time instructions were given in how to analyze case material, how to extract information from it, how to develop the questions worthy of discussion, and by direction and illustration the students were shown how to bring points of discussion before the group and how to control discussion. It has been found that training in these techniques takes away very little time from the subject matter of the course. Starting about the fifth week of the course each student in the class was assigned responsibility for leading one of the discussions of cases which would be considered for the remainder of the quarter. These cases were interspersed with discussions led by the instructor on basic

principles which had to be highlighted in the course content.

Prepared Outline Required

In order to insure proper preparation for the leading of the discussion, the instructor requires that the student turn in his prepared outline of the discussion at the end of the period during which he has led the discussion. In addition to this, the student discussion leader is also required to turn in a short report in which he analyzes what his objectives were in the conference and the manner in which he accomplished these objectives and, most important, things he failed to do to fully attain the objectives he had set forth for discussion. These procedures will carry through into the second quarter of the course and will insure that each student has at least two opportunities to lead the discussion.

In the course in Wage and Salary Administration the instructor again leads the discussion for the first part of the course. The instructor also gives to the student an outline containing the most essential points of the various subdivisions of the subject. Inasmuch as this is only a one quarter course, and inasmuch as it is given in the senior year, student leadership of the discussion starts earlier in the course, usually during the second week of class meetings. During the first week the students select the area of the subject in which they prefer to lead the discussion. In this course no case studies as such are given to the students to serve as a basis for discussion. A list of references, magazine articles, and other periodical material is given to the student and it is up to the discussion leader to bring such current case material into the discussions as he feels desirable to accomplish the objectives of the discussion for the period. This is done deliberately in order to develop in the student a realization of the necessity for obtaining material to illustrate and further the understanding of any group discussion which he may lead. Again, in this course the leader is required to submit an analysis of his objectives and their accomplishment at the termination of his discussion.

In the course in conference leadership, the subject matter for the discussions is industrial personnel problems or matters of local or national interest occurring at the time. The idea is to give the student opportunity and practice to develop material of current interest and to use it in conferences as he might when he gets into industrial employment.

It is perhaps obvious that the above three courses have in their content more material of a subjective nature than many of the courses in other areas of engineering; and the question perhaps arises, can this experience be given to students in the more objective type of course?

Some experimenting has been done and the answer seems to be yes, but to a more limited extent than in the subjective type course. For instance, in such courses as motion and time study, engineering economy, tool engineering, or quality control, it has been found possible to treat the matter somewhat as follows. The instructor develops the essential theory and discusses it with the class in the usual manner. Following the discussion of the theory certain problems are assigned which illustrate the application of the theory. The problems are, of course, then reviewed to insure understanding of the theory and its application. It is in this discussion of the application of the theory in terms of the problem that students assume leadership of the discussion. This has been attempted and found to be an opportunity to give practice to the students in this regard.

Evaluation

It is, of course, impossible at this point to give any factual estimate of the success of this approach. The ultimate test, and of course the only true test, will come when the students who have had this opportunity graduate and get into situations which test the ability which we have been attempting to develop.

It should, of course, be obvious that the success of any program of this type is

dependent upon reasonable class size. It has been found that more than twenty in the class makes such an attempt virtually impossible, with fifteen being the ideal maximum. Individual participation in the discussions seems to vary almost inversely with the number of students in the class group. The only conclusions available so far seem to be that the students who have participated in this type of course presentation seem to be more articulate and seem to have more confidence in their ability to state their opinions. They have definitely improved their ability to stand on their feet and control discussion. Further, the students who have been in the classes where this technique has been tried seem to have developed more interest in the subject and have definitely stated their liking for this type of class presentation.

This idea is not new nor has our experiment resulted in a finished technique. A great many more students must take part in this conference method of instruction; a better cross section of courses must be explored, and an extension of the idea has to be developed in other courses in order to evaluate the real potential of this method.

Electrical Engineering Division Summer School at Dartmouth

The Electrical Engineering Division of the ASEE held a Summer School on "Teaching of Electric Circuits and Fields at the Undergraduate Level" at Dartmouth College on June 20 and 21, 1952. Planned to occupy two days and one evening, the sessions were attended by over 60 electrical engineering teachers. In addition, an informal discussion period developed on the second evening which added materially to the value of the school. At this informal meeting the subjects discussed ranged from special teaching methods to a description of electrical engineering curricula and teaching in Canada as contributed by a Canadian representative.

Friday was devoted to a study of the teaching of electrical circuits and Saturday was given over to a discussion of the teaching of electric and magnetic fields. Single speakers occupied the morning in order to have time to fully cover the assigned area and to permit considerable discussion. The afternoons were given to two speakers in each case, to cover particular assigned areas.

Dr. M. B. Reed, of the University of Illinois, on Friday morning reviewed fundamentals in the teaching of electric circuits, including the necessity for clearly defined notions of polarity and circuit notation. In the afternoon Professor E. M. Strong, of Cornell University, discussed "Use of Loci in Circuit Analysis," and Professor R. M. Wainwright, of the University of Illinois, demonstrated the use of matrices in circuit analysis with particular emphasis on polyphase circuits and symmetrical components.

On Saturday morning Dr. W. B. Boast, of Iowa State College, reviewed the general subject of teaching of "Quasi Static Fields," giving methods applicable to the introduction of the subject at the sophomore level. In the afternoon Dr. G. B. Hoadley, of North Carolina State University, discussed the teaching of dynamic field theory in the senior year, and Dr. J. F. Calvert, of Northwestern University, discussed flux plotting and gave some interesting illustrations of the method.

On Friday evening Dr. A. R. D'heedene, of Bell Telephone Laboratories, discussed certain applications of network theory as employed in circuit design. J. D. Ryder, of the University of Illinois, served as Chairman for the Summer School.

Training Engineers for More Effective Results in Industry*

By MR. ROBERT C. SPRAGUE

President, Sprague Electric Company, North Adams, Mass.

Before beginning to talk about educating engineers, let me state what I think we are trying to educate *toward*. I accept, as not likely to be bettered, Tredgold's definition of engineering as: "The art of directing the great sources of power in nature for the use and convenience of man." This definition excludes the pure scientist. And I am further limiting my thoughts to the engineer who, on completion of a four-year course in one of our 148 accredited engineering schools, contemplates employment in industry.

From the report written by your Committee on Aims and Scope of Engineering Curricula, back in 1940, I infer that, as a group, you also accept Tredgold's definition. I have read that report with the greatest interest and with high appreciation. And I know that the recommendations of that committee have had the direct effect of putting more stress on the humanistic subjects in engineering curricula. That effect is being continually evidenced as more and more schools adopt this broader policy.

My own experience leads me to accept as axiomatic the concept of increased grounding in the humanities for men who must be concerned with such diverse human needs and activities. In our own plant, for instance, one man might apply himself to the components of end-products as diverse as television sets and proximity fuses, radios and guided missiles, or electric razors and atom bombs.

In reading the recent bulletins of a few of the major engineering schools, I have been gratified to see that (largely through the effectiveness of your efforts) considerable importance is now given to such subjects as literature, history, economics and labor relations. And I was particularly pleased to see that several of the more advanced schools, including M.I.T., have adopted the idea that a student should prove his competence in oral and written expression before receiving an engineering degree.

Though I appreciate the progress which has been and is being made in the direction of humanistic study, there is one side of an engineer's education about which I can find very little discussion in the bulletins I have read. This is the training which should increase both his desire and his ability to work effectively with other men.

So much has been said and written about this facet of the engineer's personality that nearly anything I add will be repetitious. But in my own experience I have found a condition so general and so disturbing that I cannot withhold my opinions. I have too often found it exceedingly difficult to get an engineer to work aggressively on any idea suggested by someone else. There is too frequently the N.I.H. (Not Invented Here) factor which prompts him to waste considerable amounts of the company's time and money to prove the superiority of his own ideas. And in his relations with other departments I have found the engineer tends to minimize the opinions of others, especially those of the so-called practical

* Presented at Annual Meeting of A.S.E.E., at Dartmouth, June 1952.

man. By which I mean the man who has acquired sound engineering principles from experience which may have been very extensive, though possibly limited to his company's particular field of activity.

I know you must have heard this comment often from management. I do not know whether your regard it as justified.

Perhaps you agree that this situation does generally exist, yet hold the view expressed by Prof. Drucker in his article in the May-June issue of the *Harvard Business Review*. There, as you probably read, Prof. Drucker takes the position that, both by inclination and training, the professional man is a different creature from the administrative man. Prof. Drucker considers it right that the professional man should be: ". . . trained to work on his own . . ." and that "he does not . . . take kindly to modern organization—and especially not to large scale organization." So, according to Prof. Drucker, Administrative Man must take Professional Man just as he is—and like him. This alone would be disturbing. But I find real cause for alarm in Prof. Drucker's further implication that the ultimate aims of these two groups are mutually exclusive.

May I quote again from Prof. Drucker: "The problem is thus one of basic attitudes. . . . To make matters still more difficult, the attitudes that cause the difficulties are in themselves desirable." And finally I find this opinion expressed by Prof. Drucker: "Professional employees do not fit into the administrative process—and the administrative process does not fit them. In particular, the very concept of 'supervision' goes against the grain of professional employees. In many ways this matter of the 'supervision' of professional employees illustrates the entire problem, for it is a good example of the businessman's failure even to realize that the professional employee presents a problem. 'Supervision'—both the term and the institution itself—is automatically applied to professional employees because it is the established thing for other employees. Yet not only is it resented by professional people; it is not the appropriate organization pattern for them."

Let me assure you that Prof. Drucker is mistaken in his belief that businessmen, as a group, fail to recognize that this problem exists with the professional employee. As I mentioned very early in my talk, I hear that problem often and earnestly discussed both within and outside my own organization. Indeed, these businessmen, because of the very nature of their jobs, are required not only to recognize, but to cope with the problem. Their jobs entail the coordination of individuals into departments, and departments into a unified organization. And so they find it necessary that the parts of a business function smoothly in relation to each other to produce a satisfactory overall result.

In the various phases of design, production and sale of component parts (such as those made in our plant) each member of the engineering staff must have considerable knowledge and constant awareness of the relation of the part on which he is working to other components and to the end-product as a whole. So is it not reasonable to expect him to have similar knowledge and awareness of the functions of other individuals and departments vital to the organization of which he himself is a part?

I hope you do not agree with Prof. Drucker because I feel very strongly that his concept is not merely an unfortunate one, but actually a dangerous one, both for the engineers themselves and for the industry they serve. And I am encouraged to find that my view is validated by at least one of our leading schools. May I read you a statement which I found in the 1952–'53 *Bulletin of the Columbia School of Engineering*?

"The successful engineer must possess to an unusual degree two basic characteristics. First, he must have a capacity for teamwork, an ability to work effectively with others on a common problem in an organized group. The keynote of modern re-

search is the concentration of many minds on a single problem. In construction or manufacturing a capacity for and interest in cooperative endeavor is essential also. An ability to work in, organize, or direct an engineering force, and to aid in establishing esprit de corps is an essential to progressive and productive engineering practice."

If, as I hope and believe, many of you will support that statement, then how shall we approach the problem of correcting, or at least alleviating the situation?

Is it to be expected that the new emphasis on the humanities will improve the engineer's attitude toward his co-workers? Or will the problem have to be more directly approached?

Whatever you answer to this, I am convinced that the observations and experience of industry could be advantageously utilized in the education of young engineers.

So I urge that industrialists be allowed to participate actively in your program for the better integration of the engineer in the company for which he will be working and in society as a whole. For, as an employer interested in training the engineer for more effective results in industry, I do not want him only to be more effective in my own organization. I am interested in showing him the fuller rewards which might be his if he would regard himself, not merely as the *first* citizen of the laboratory, but as *first, a* citizen of the world.

There is one other facet of the subject on which my experience as an employer may qualify me to speak. This is the delicate balance of emphasis on the basic and applied sciences as against applied engineering in a four-year curriculum.

It is estimated that at least 65% to 70% of the engineers who graduated in 1949 and '50 accepted industrial employment. (This specifically excludes federal and state government employment.) Am I correct in interpreting this to mean that, in effect, engineers are being educated today primarily for industry? And if so, does this not add considerable weight to industry's opinion as to the placement on this emphasis in the present curricula?

Stress Basic Sciences

As an employer of more than 100 graduate engineers, I am among those who hold that the education of tomorrow's engineer should stress the basic sciences, even if this can only be done at the expense of applied engineering subjects.

From my own observation I find dramatic evidence that the man with the strongest basic training has the greatest adaptability. Because the basic sciences can be applied to different problems in many branches; or to a single problem which may extend into overlapping branches. In the rapidly changing technological industries such a man enjoys a tremendous advantage.

In our own plant this kind of flexibility, resulting largely from basic training, is conspicuous. One of our most capable men in the electrical field has a chemical engineering degree; and one of our top chemists holds a degree in electrical engineering.

I am of the opinion that this adaptability is important to industry even when there is no dearth of engineers. But when the shortage is as acute as it is now, the man with adaptability unquestionably commands a high premium.

Dr. Preston Robinson, our Vice President in Charge of Engineering, holds the view that good training in the basic sciences qualifies the student for mastery of all branches of engineering and that these principles should be stressed because they are least susceptible to change. He feels strongly that the four-year engineering course should be a broad, professional training; and that specialization should come only from advanced university work, or from practical experience.

If this view were accepted by the engineering schools, the student should be made to understand from the beginning of his course that a high degree of specialization in four years is not desirable; and that it is assumed, both by the school and

by industry, that a four-year diploma will mark only the commencement of his engineering education.

I suggest that industry's attitude is clearly shown by the fact of its encouraging and underwriting of employee-participation in extensive programs for post-graduate study. Such programs, inaugurated by a considerable segment of industry which employs graduate-engineers, are being carried out partly in classes conducted within the employing organization, and partly by attendance at nearby engineering schools.

Graduate study at established schools is being encouraged in two ways: by granting time off for the purpose; and by payment of part of the tuition costs. Let me cite only a few examples.

Because of its far-flung organization, Westinghouse (which was a pioneer in the field of education for professional personnel) has developed a program for cooperation with nine institutions. These are:

University of Pittsburgh
New York University
Polytechnic Institute of Brooklyn
Stevens Institute of Technology
University of Pennsylvania
The Johns Hopkins University
University of Buffalo
Case Institute of Technology
and
University of Delaware

With the result that since 1927 6000 Westinghouse engineers have taken advanced courses at these institutions. And in most cases half the tuition has been paid by Westinghouse on completion of the courses. Of these 6000 students, 200 have earned advanced degrees—including 20 doctorates.

At Bell Laboratories engineers are given five hours' absence a week (without salary deduction) for the purpose of advanced study. Under this plan 96 Masters and 15 Doctorates have been earned by men employed full-time at Bell Labs.

The list of firms cooperating in this way with engineering schools comprises a sort of Blue Book of the industry. To give some idea of its length, I point to the city of Milwaukee where as many as 50 firms are sending engineers to the University of Wisconsin Extension School. I am told that it is usual at Wisconsin for two-thirds of the tuition to be paid by the employing companies: one-third at the time of enrollment and one-third on completion of the course.

The most recent figures I have seen from the University of Pittsburgh were for the year 1948–'49. At that time there were 614 engineers enrolled there from six different industrial firms which paid half the tuition on completion of advanced courses.

Work Closely with Schools

In our own plant, Dr. Robinson and other heads of engineering departments are eager to work more closely with the schools. Up to now we have employed undergraduates in summer; we have sent graduate engineers to the M.I.T laboratories for advanced research work; and two of our men have been given leave of absence for graduate work at M.I.T. We also allow up to three hours per week with no loss in pay for study at nearby Williams College and pay all tuition charges for approved courses there, at R.P.I. and at Extension Schools, one-half on enrollment and one-half upon satisfactory completion of course.

Presumably even more of such encouragement and help might be given by industry to its engineers, but for the fact that many centers of engineering activity are still without facilities for advanced study after work-hours. This possibility has been suggested by a brochure: "The First Five Years of Professional Development" issued by the Engineers' Council for Professional Development. In this I found a list of 50 industrial centers, only 24 of which offer facilities for graduate engineering study in the evening.

In many of these locations where no evening courses are offered, there are already accredited schools for engineering degrees. I suggest that some of them

(such as Brown, Yale, University of Cincinnati, University of Akron and Washington University) be approached with the possibility of offering graduate courses in the evening. While at the same time industry in these centers should be informed of the possibility that new advantages may be offered, and urged to subsidize advanced training for their engineers.

Even this cursory review of the widespread program of industry to foster graduate training might be construed to indicate that industry collectively does not regard the four-year engineering graduate as a very highly developed specialist. The program certainly means that, in effect, industry is giving much attention to, and assuming considerable responsibility for, developing the sort of specialists it needs. So is it not realistic to suggest that the schools throw more of the post-graduate burden on industry and place their emphasis on basic training? This would qualify the graduate to specialize in the direction of those talents which are later found best adapted to the shifting requirements of industry.

Conclusion

In conclusion, I should like to summarize.

My personal observation leads me to place particular importance on three aspects of a four-year curriculum if a primary objective is to make the engineer more effective in industry:

1. The continued increase of humanistic subjects, with sufficient emphasis on economics and business organization to heighten his appreciation of the vital functions performed by all departments in any successful industrial enterprise.
2. Direct or indirect exercise in teamwork—beginning with the members of his own squad or department, and then extending beyond the limits of his organization into his community.
3. More intensive training in the basic and applied sciences—even at the expense of high specialization in the applied engineering subjects.

From the March issue of *The Journal of Engineering Education* I see that a new committee is being formed, under the chairmanship of Dr. Grinter, to make an "Evaluation of Engineering Education." I hope that this will not be an all-academic group. Because I am convinced that our common purpose can best be served by taking a stereoscopic picture from the view-points of both the educator and the industrialist—which points are, I contend, only a short distance apart.

In closing, I again emphatically reject Prof. Drucker's dark opinion of the irreconcilable variance between the professional and the managerial attitudes. But if he is right and I am wrong, may it not then be argued that attitudes are the concern of both school and industry?

Might not your new committee (I should prefer to call it *our* new committee) take time to study the relation of curricula to attitudes? And should we not, *together*, measure and weigh the equipment and attitudes of the young engineer against the requirements and attitudes of industry? I hold it *likely* that we should find these attitudes far from irreconcilable. And I hold it *certain* that, merely by recognizing the problem as our joint responsibility and approaching it together, we shall have taken an important step toward its solution.

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College Notes

Dean Andrey A. Potter of the **Purdue University** Schools of Engineering will retire from his duties next June 30 and will be succeeded by Dr. George A. Hawkins, Professor of Thermodynamics and Associate Director of the Engineering Experiment Station. The retirement of Dean Potter will bring to a close a career lasting 50 years which has placed him among the nation's top engineering educators and brought Purdue to new heights as a center for engineering education in the U. S.

Dean Potter was born in Europe and came to the U. S. at the age of 15. In 1903 he was graduated from the Massachusetts Institute of Technology with the Bachelor of Science degree. He has received honorary degrees from Kansas State College, Northeastern University, Norwich University, Alfred University, Rose Polytechnic Institute and the South Dakota School of Mines. Dean Potter was employed by the General Electric Company from 1903 to 1905 when he joined the teaching staff of Kansas State College as an assistant professor of mechanical engineering. In 1913 he became Dean of Engineering and Director of the Engineering Experiment Station. He came to Purdue in 1920 in the same capacity.

Dean Potter is author of a number of books on power engineering, thermodynamics, and farm motors, and of more than 300 engineering, educational, and scientific papers and articles. He has held many positions of trust in the United States government, including that of Chairman of the Advisory Committee for the Engineering, Science and Management Defense Training Program, 1940–1946, and executive director of the National Patent Planning Commission, and recently was confirmed by the U. S. Senate for a six-year term as a director of the National Science Foundation. His professional honors are too numerous to include here. He is a Past President of the ASEE and received the Lamme Award from the Society in 1940.

Education for Educators*

By ALI BULENT CAMBEL

Assistant Professor of Mechanical Engineering, State University of Iowa

There is considerable evidence that not all those concerned with engineering education are satisfied with it. Industry is not happy with the product it hires. Graduates are not happy with the training they have received. Americans as a whole are complaining that their children are not being properly educated and that they are not developing into productive citizens. Above all teachers of engineering are not convinced that they are doing their best job. Paradoxically, this dissatisfaction should make everyone concerned very happy, because as long as engineering educators are aware of their responsibilities, rather than being smug and self-satisfied, things are bound to improve.

Engineers, during the past few years, have made a definite effort to improve engineering education. A very notable contribution is the report of the ASEE Committee on Improvement of Teaching (1). The problem as clearly presented in this report is a difficult one to tackle. There is no school or institution where one may study the teaching of engineering. There are numerous courses in education. One can actually prepare for a career in elementary or high school teaching, but it is impossible for those desiring to teach engineering to train themselves for the job. Moreover, learning to be an engineer requires so much time that it is almost impossible for a budding teacher to enroll in formal courses in pedagogy in which he could learn the fundamentals of teaching. Therefore, improvement of engineering teaching must be undertaken after one has assumed a teaching position. In a way it is typical "on the job training" and many avenues are open to better teaching. One particular approach to the improvement of teaching has been instituted in the College of Engineering of the State University of Iowa (2).

The ground work for the course was laid by a local committee consisting of one assistant professor from each department of the college. This committee met for several months prior to the inauguration of the course and continued meeting during its progress.

The initial work consisted of defining the objectives of teacher training and of finding the means by which these could best be achieved. After debating numerous possibilities, the committee agreed to conduct a course which would combine the techniques and philosophy of engineering instruction. The committee then held discussions with the dean and with the department heads of the College of Engineering, and their opinions were consolidated with the objectives already set forth. As a third step the College of Education was consulted for suitable topics for the projected course.

Organization

The preliminary organization led to the following decisions: that the course be aimed especially at young teaching personnel consisting of assistants, instructors, and assistant professors, but that faculty members of higher ranks be invited to attend the meetings; that the course in its trial period extend over one complete semester, with one meeting every week;

* Presented at the Conference of Young Engineering Teachers, ASEE Annual Meeting, Hanover New Hampshire, June 26, 1952.

that attendance in the course be purely voluntary; that no remuneration nor reduction in teaching load, because of participation in the course, be requested from the school administration; and that the course consist of formal lectures given by senior members of the College of Education and of discussion periods led by department heads in the College of Engineering.

The lecture topics in the order of their presentation, were as follows:

Introduction
The need for teacher training; problems faced by the instructor; history of education; great names in teaching and their philosophies; use of teaching aids.

Educational Psychology
Psychological factors in students; mental ability and its criteria; aptitude and aptitude-testing; the effect of social and economic background on college study.

Reading and Retention
Problems involved in reading ability; methods of improving reading; the relation between reading and understanding; retention of material read or heard.

Adult Education
The aims and objectives of adult education; difference between college education and adult education; techniques of adult education.

Examinations
The purpose and method of preparing examinations; objective and nonobjective examinations; grading; criteria of good examinations.

Aims of Teaching
Criteria of good teaching; should students be taught to think? Teaching in a divided world; academic freedom.

Administration
The private institution and the State institutions; statistics pertinent to education; appointments, promotions, and salaries; the educator as a citizen.

Discussion meetings were held periodically during the semester, two department heads serving as discussion leaders in each meeting and answering questions raised by the audience. Among the questions considered were those concerning the relative merits of lecture and discussion methods of instruction in nonlaboratory courses, the amount of assistance the instructor should give with an assignment before the student has undertaken it, the role of home work, the use of the curve and of other standards of grading, and the proper amount of credit on teaching load for laboratory courses.

Although the program at Iowa was voluntary, attendance at the meetings indicated interest. Senior faculty members, however, were rather more interested than were the young instructors. To some extent this may be attributed to the fact that many young staff members often perform dual jobs because many of them teach while they study towards advanced degrees. Thus they have little time to study teaching techniques.

In the sessions no textbook was used and no assignments were made. However, two booklets were suggested and indications are that most staff members acquired them. These are "Effective Teaching" (3) by F. C. Morris and "Instruction Manual" (4) of the Georgia Institute of Technology. Further articles from the *New York Times* such as those by Benjamin Fine and by Gilbert Highet were discussed.

Observations

It might be worth mentioning that the student body reacted favorably to their faculties striving for better teaching. In fact the university student daily ran an editorial in which it commended the engineering faculty and expressed the hope that other colleges might follow suit.

Such a training course is obviously not the only means for the improvement of teaching. In fact no one method is sufficient to develop a great teacher. Development of great teachers can not come from outside stimuli, but must come from

within the budding pedagog. The greatest responsibility lies with the teacher himself and not with anything or anybody else. Nevertheless, training programs, seminars, etc. do contribute greatly and serve as a forum for discussion.

Furthermore, teacher training programs are very advantageous in bringing to the attention of staff members the best and the latest in education. It should be emphasized that the improvement of teaching need not be attempted in general sessions dealing with pedagogy only. Other programs such as the summer schools organized by the various specialized divisions of the ASEE greatly contribute to better teaching and enhance the capabilities of teachers.

The distinguished philosopher-mathematician Alfred North Whitehead (5) points out that a person must be good in everything and excellent in one. It is more difficult for an engineering teacher. He must be good in everything and excellent not in one but in two things. Being good in everything means being educated physically, mentally and morally. Being excellent in two things means that an engineering teacher must be an excellent engineer and must be an excellent teacher. These are requirements with which it is difficult to comply.

In retrospect it may be said that the Iowa program brought faculty members closer to one another through the concern with common problems and the realization of the fact that there is no one or easy road to good teaching.

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College Notes

John F. Gordon, vice president of General Motors and chairman of the board of regents of **General Motors Institute** announced expansion of the Institute comprising a new building of 83,000 square feet to be added to the present structure. The addition will add approximately 40 per cent to classroom, laboratory and general service areas and the over-all expansion plus the remodeling of the present building will be a total structure of modern acceptable standards equipped throughout with the most recent and effective type of engineering educational facilities.

The expansion at General Motors Institute will result in greater emphasis in the curricula on the experimental approach to problems ahead. Wide laboratory areas will be provided unhindered by unnecessary partitions that might restrict maximum flexibility. These areas will include the most modern equipment necessary for continual adaptation of the curricula to assure that the preparation given the student is kept abreast of the increased technical demands that will be made upon the future graduate.

English and History as Professional Equipment for the Engineer*

By HENRY DAN PIPER

Assistant Professor of English, California Institute of Technology

President James B. Conant's excellent little book, "On Understanding Science," is based on the premise that a scientific education trains a student to think somewhat differently from his fellows in the liberal arts. The humanist who has been fortunate enough to have worked closely with scientists and engineers will readily endorse this proposition. He finds much to admire in certain unique habits of mind which he recognizes as the distinctive—indeed, the most important—fruits of a modern scientific or engineering education. He respects his scientific colleague's ability to analyze a complicated situation into components that can be easily identified according to clearly defined and readily verifiable standards. He particularly admires the scientist's ability to establish fruitful relationships between these various components. And he looks on in awe as the scientist's synthesizing imagination successfully utilizes these new relationships to create a new and meaningful intellectual order where before there had been only uncertainty and confusion.

These, of course, are invaluable habits of mind. By means of them, during the past two centuries, scientists and engineers in laboratories, factories and drafting rooms have revolutionized western civilization.

Yet because of the immense success of the scientific method, engineers and scientists are moving out of the drafting room and laboratory today in increasing numbers. More and more we see them assuming new, different and increasingly powerful roles in society. For better or worse they are becoming "humanized," at least in the sense that they find themselves today engaged to a greater extent than ever before in the buzz and hum of everyday human activities. Moreover, technical schools, by their vigorous expansion during recent years, have tacitly acknowledged the importance of these broadened responsibilities. No one would maintain today that scientific and engineering students are being educated solely for careers in research and development. Most of them look forward confidently to jobs in which they will be expected to work closely with, and may eventually supervise, lawyers, salesmen of all kinds, accountants, advertising copy writers, personnel advisers, and all the other familiar non-scientific specialists so essential to the functioning of any busy industrial enterprise.

It is in the light of these altered professional needs that the humanist today finds himself scrutinizing engineering education. Are the peculiar habits of mind noted by President Conant as the distinctive characteristics of a scientific training really adequate professional preparation for the present-day scientist and engineer? Basing his opinion upon his own recent association with a number of these specialists in government and industry, the humanist finds himself obliged to answer in the negative. It seems to him that technical education today is not fulfilling its professional obligations when it does not supplement its traditional specialized training with certain other habits of mind based on more

* Presented at the Annual Meeting of ASEE at Dartmouth, June 23, 1952.

humanistic disciplines. His reasons for thinking so are not the familiar ones that usually accompany a plea for the cultivation of the humanities—profound and pressing as those arguments may be. Indeed the humanist is not even sure that most departments of English and history are prepared to provide the kind of supplementary discipline that he has in mind. For what he seeks is training that will teach the technical student to use the resources of good English and a sense of historical relationships to order and to communicate his specialized technical knowledge and thereby give it broader social meaning than is possible by strictly scientific habits of mind. Our humanist's arguments for such training are, consequently, narrow and very realistic professional ones. And they are based upon his conviction that scientists and engineers being educated today are destined to play more diversified and more socially responsible roles in our economy than ever before.

A Problem of Communication

The particular humanistic habits of thought increasingly needed in their professional activities by today's scientists and engineers may be conveniently classified under that much-abused but still useful label, "communication." We often overlook the fact that "communication," in a very important sense, is only a newfangled name for a much older and really much more complicated idea, that of "leadership." What, after all, is more characteristic of the good leader or executive than his ability to comprehend and to communicate effectively to others the special skills, qualities and know-how possessed by those working under him? When we admit, as we must today, that modern specialized education has failed to overcome the obstacle of communication, what we are really saying is that we are not training our students for executive responsibilities—for leadership in their respective professions. It is at this point that the humanist feels himself justified in offering a few suggestions. Leadership has always been his pre-eminent concern.

One of the most common shortcomings that the humanist observes in his daily professional contacts with scientists and engineers is the absence of good writing habits. It is easy to understand science's age-old suspicion of written language. Words are slippery, and they have vague and manifold meanings. Science long ago supplanted them with arbitrary mathematical symbols which could be counted on to preserve constant, precise meanings. And the language of mathematics has proved serviceable in the laboratory and drafting room. But the engineer or chemist who depends solely on this private method of communication is bound to run into trouble, especially if he is one of the cogs in the average industrial enterprise. After all, the odds are that most of his research and development work has been requested by sales, operations, legal or some other affiliate. If the research worker or the development engineer cannot make his specialized data meaningful to these more secular colleagues, he will find himself seriously handicapped. The humanist doesn't have to work very long with scientists and engineers before he notices that here, as elsewhere, advancement opens up most rapidly for the man who has demonstrated not only technical proficiency but also a capacity for relating his specialized efforts to those of his other coordinate departments.

We are all acquainted with the typical case of the young engineer who is unhappily anchored to a routine job in the laboratory control room or on the drafting board. We see him constantly passed over as opportunities for advancement open up, mainly because his value lies exclusively in his technical proficiency. He is, of course, the one who cries loudest every Thursday at "weekly report" time, and his contributions usually must be entirely rewritten by his boss. The humanist is inclined to regard this man as little more than a mere "technician," whether he is a Bachelor of Science

trained to manipulate scientific equipment, or a full-fledged Ph.D. trained to manipulate scientific ideas. In either case, if he can function only within the narrow limits of his scientific discipline and cannot, when necessary, give a larger, more complicated and more human meaning to his activities through the resources of the common tongue, then what is he, after all, *but* a competent "technician?" Is he really qualified for more varied and interesting executive responsibilities?

The Historical Sense

No less important than good writing habits as a means of communication is the historical sense. By this I do not mean merely the detailed factual knowledge of various political, military and other interesting events in the past. It is the historical sense which gives such events meaning. More precisely, the historical or time sense is that instinctive sense by means of which we habitually order and communicate past experience.

This sense, particularly in our modern historically-orientated society, is one of the most useful ways of giving a certain limited but familiar meaning to human activities of any kind, and its use should be one of the intellectual disciplines available as a form of communication for any educated man. In our increasingly specialized civilization it is practically impossible for anyone in an administrative post to possess detailed, complete knowledge of the technical activities of his various subordinates and associates. In place of such specialized knowledge the good executive must be able, when necessary, to substitute historical understanding. For the same reasons, he must also be able to reshape his own specialized knowledge historically for the benefit of his non-scientific colleagues and superiors. This requires not only good writing habits but also a well-developed awareness of the social and other contextual needs and desires out of which any given technical problem has invariably arisen. It is difficult to see how a scientist or engineer can function effectively as part of any larger cooperative enterprise if his own specialized functions cannot be readily interpreted in these broader terms.

Those of us who have watched specialists struggling with the writing of histories of their technical activities can testify to the inadequacies of a scientific education when it comes to developing a historical frame of reference. For instance, during the recent war a number of top-flight scientists and engineers heading up the various research groups of the army's atomic energy project were requested to submit historical accounts of their non-military research activities. The resulting history had been planned as a supplement to Professor Henry Smyth's well-known report on the military applications of atomic energy. It was undertaken particularly for the benefit of legal counsel, congressmen, military and other interested non-technical authorities for whom a historical rather than a highly technical and analytical account of project policies and objectives would be most informative. What particularly impressed the humanists who were also associated with the preparation and editing of this history was the inability of otherwise competent scientists to bring historical perspective to bear on their jobs—not only in the writing of these historical chapters, but in their ordinary day-to-day administrative activities. They seemed to think only in the present and the future. Accordingly, the histories that these scientists initially turned in were little more than summaries of future objectives and present needs, usually set forth in private technical language. The relation of such needs to the earlier conditions out of which they grew, and the possibility that these needs might have been rendered superfluous by subsequent history, were rarely taken into account. As a result, trained historians who were later called in to restudy these records and prepare more adequate histories, uncovered a notable amount of pertinent data essential to the efficient operation of the project's research facilities. In some instances it was found that current in-

vestigations had drifted far afield from the objectives for which they had been originally initiated. In other cases work was going on which was no longer of such high priority and from which key technical personnel might have been released for more important research. And occasionally they found current work unknowingly duplicating previously completed investigations, merely because no final reports on the earlier projects had ever been submitted.

In other words, few of these top-flight scientists had been equipped by their professional education with the historical perspective so necessary in any executive for the efficient administration of his organization. Just as rigorous scientific training traditionally makes the scientist or engineer suspicious of words as vehicles for the communication of his ideas, so he also is naturally sceptical of the processes of history. For historical time, like so many other incorrigibly human affairs, is untidy and confusing and subject to many conflicting interpretations. The scientist wants his time, like his language, stripped of these unreliable human associations and sliced up into simple units that can be readily measured on the blank face of his stop watch. This, of course, is a very understandable preference, so long as he remains in his laboratory. But written English and the historical sense continue to be traditional means of social communication. And the engineer or scientist who aspires to executive leadership must be trained to order and express his specialized knowledge in these terms as well as by the discipline of science.

Recommended Teaching Procedure

But how is this training to be carried out without further encumbering our already over-crowded engineering curriculums? Writing has been properly the responsibility of the English Department. But it is only one responsibility, and is frequently a minor one. The teacher of English is also a teacher of literature. This usually means that he is primarily interested in developing the student's insights into man's recurring problems and his high aspirations, through the study of great literary works in which the human condition has been dramatized and otherwise ordered by the creative imagination. When the teacher of English undertakes a course in writing and composition, he understandably centers it around the formal study and imitation of those traditional techniques by means of which these problems and aspirations have been transformed into literary art. Such courses relate only remotely to the technical student's need for instruction and practice in the application of good writing habits to the content of his professional studies. Besides, few English teachers are prepared—technically or temperamentally—to give him such instruction.

History departments, by and large, are subject to the same criticisms. Through appropriate courses they provide disciplined study of the many interacting forces that, in the past, have given rise to significant military, political and other important events. But they are not primarily interested in training the engineering student to be his own historian. They tend to assume the existence of a historical sense, instead of providing for its exercise and development. This may be a valid assumption in the case of a liberal arts student (although I personally doubt it); certainly it has been proved unwarranted with respect to scientists and engineers.

In view of these familiar pedagogical obstacles, my suggestions for a solution to the problem are the following. In general, I would require of every scientific and engineering student that he demonstrate, before graduation, a certain proficiency in the application of good English and a historical sense to the data of his special technical field. More specifically, I would have each student, sometime during his last two years in college, submit at least one full-dress essay dealing with some problem of this nature. His paper may be based on li-

brary research, or it may be the result of both outside reading and laboratory experiment. The subject may be a personality, an idea, an institution, or any combination of these topics. But, above all, it should be a subject of genuine professional interest; one that has aroused the student's enthusiasm and stimulated his imagination. Only then will he care enough about what he has written to benefit from criticism and advice.

The solution outlined so sketchily here is only a tentative one, and can be easily modified. At this stage of the discussion the particular habits of thought that such essays should develop are much more important than the several alternatives by which they can be secured. The main advantage of the full-dress extra-curricular research paper is that it can be introduced as a blanket requirement at any time without raising the question of new or changed course-work. An attractive alternative might be the optional substitution of a paper, or papers, prepared in already established courses—such as courses in technical or advanced English composition, or in the impact of science and technology on the history of western civilization.

Finally, I would require that the essays be read and judged by the student's professional advisor as well as by a second reader drawn from either the English or history staffs. A satisfactory essay should give evidence not only of the writer's technical proficiency, but also of his ability to place his data in a historical framework, and to write about it clearly, accurately and interestingly. Without this ability can we say that any student has really mastered his professional discipline, or that he is educated in the true meaning of that word?

Reserve this date . . . .

June 22-26, 1953

ANNUAL MEETING

UNIVERSITY OF FLORIDA

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Industry's Stake in A.S.E.E.

. . A Message to Industrial Management

By J. C. McKEON

Chairman Associate Institutional Membership Committee; Manager, Educational Department, Westinghouse Electric Corporation

The Associate Institutional Membership Committee of A.S.E.E. is now launching its major industrial membership drive, after a most successful pilot operation, which increased memberships from three to thirty-five.

The following article is being printed in booklet form for use in connection with the Committee's campaign to interest industry's top management in A.S.E.E. Associate Institutional Membership.

As an individual Society member, if your company is not listed in the Yearbook Issue of the Journal on the Associate Membership roll, page 36, would you please place this article with the accompanying application blank before the appropriate committee.

The development of technical and management talent is a most critical problem facing top management today. The future prosperity and progress of every industrial concern depends upon a constant flow of competent people and ideas into an organization. The increasing complexity of industry's problems requires a higher level of technical and professional competence. Nothing is more fundamentally vital to a company than a sound professional personnel program for leadership development.

Enlightened management recognizes its partnership with the universities in maintaining effective programs for the recruitment, training, continued education, and management development of professional people. Industry looks to the enginering colleges for a source of technical manpower and a reservoir of fundamental knowledge. Many companies, however, are not fully aware of the assistance the colleges are prepared to render. The value of satisfactory arrangements for the recruitment of seniors and the handling of research projects is apparent. Less apparent, but of equal importance, is the value of joint graduate study courses and advanced management development programs for professional employees. The education and development of our future leaders requires a cooperative effort.

Membership Dividends

Industry's stake in engineering education and the American Society for Engineering Education is vital. A.S.E.E., the official professional organization for engineering education, has guided the college engineering programs to their present high level. Membership in this great Society is not only an honor, but offers many tangible benefits to industry. A.S.E.E. provides a channel of communication with the policy makers of the universities, a forum for discussing problems of mutual interest, and the machinery for implementing programs. Effective programs with the colleges can be maintained only through industry's close cooperation with the college deans and the faculty members. Participation in A.S.E.E. gives the industrial manager an opportunity to gain firsthand, an understanding of the problems of the colleges and to inform the college personnel of his company's needs and problems. Association with the college

faculty members in the common cause of the engineering profession promotes mutual understanding and respect.

Associate Membership representatives will find participation in the Relations with Industry Division of the Society rewarding. It is composed of an active group of industrial and college faculty members. In addition to building good relations between industry and the colleges, a number of noteworthy studies concerning industrial training, qualities necessary for success in industry, a speaker's manual, teaching aids, technical job descriptions, selection of college graduates, and graduate study in industry were conducted.

In addition to the activities of the various divisions, Associate Members will be interested in participating in the Society's annual meeting, which is held on one of the college campuses, and the periodically scheduled regional meetings at various educational centers throughout the country. Each year, the Division of Relations with Industry sponsors a College-Industry Conference, in addition to its conferences at the Annual Meeting of the Society. These activities are attended by representatives from industries throughout the country. Associate Institutional Members receive a subscription to the *Journal of Engineering Education,* the official publication of the Society, and a copy of the *Proceedings* without extra cost.

Associate Institutional Membership entitles industrial concerns to participate in two of the three governing bodies of A.S.E.E., the Engineering College Administrative Council, and the Engineering College Research Council. The third governing body is the General Council, an elective body, in which Associate representatives may serve. The Engineering College Research Council is comprised largely of directors of research, deans of engineering, and research directors of industry. This Council makes recommendations to the engineering colleges regarding research policies, and serves as a common meeting ground for those interested in research developments.

Industrial members will find that along with the many advantages Associate membership provides, there is the opportunity to serve education and the engineering profession by assisting the colleges in the development of young men and women for professional careers and good citizenship.

Organization of A.S.E.E.

The Constitution of the Society provides for two classes of members—individual and Institutional. Although the majority of the 7000 Individual members are college administrators and faculty members, a substantial number of industrial people hold Individual membership. There are three types of Institutional members: Active—for accredited engineering colleges (every engineering college in the U. S. having one or more accredited curricula is a member); Affiliate—for educational institutions which are not eligible for Active membership, which includes 27 members; and Associate—for industrial organizations with a major interest in engineering education. Associate Institutional Membership presently includes the 35 companies listed below.

Associate Institutional Membership dues are $50 a year. The Society's fiscal year is from July 1 to June 30. Companies applying for membership after February 1 will be billed for one-half year's dues and will receive a copy of the *Journal* starting with the February, 1953 issue.

The Associate Institutional Membership Committee extends your company a cordial invitation to participate as an Associate Member in the activities of A.S.E.E. Please complete the application blank today—Associate Membership in A.S.E.E. is an investment in your company's future.

Please return this application to:

THE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

Application for Associate Institutional Membership

Professor A. B. Bronwell, Secretary
American Society for Engineering Education
Northwestern University
Evanston, Illinois

The undersigned company or association desires to become an Associate Institutional Member of

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and hereby agrees to conform to the requirements of membership, if elected.

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Unit Operations for Mechanical Engineers

By CHARLES A. BESIO

Associate Professor of Mechanical Engineering, Southern Methodist University

AND

DR. HAROLD A. BLUM

Graduate Lecturer in Mechanical Engineering, Southern Methodist University, Research and Development Department, The Atlantic Refining Company

Unit Operations for Mechanical Engineers

To speak of teaching Unit Operations to mechanical engineers may produce two reactions; from the chemical engineers the cry that we are trying to mix fields; from the mechanicals, assuming they know what Unit Operations involves, the query, "what's that have to do with us?" We would like to show that such training is now necessary and that it is another case of needed preparation of one group to work with another.

Lately, an increasing number of mechanical graduates have been integrated into process industries and allied fields. This has emphasized a serious shortcoming in their training. These men find themselves ill-fitted for their tasks. This is true, either because in their training they were exposed to few if any of the basic processes employed in this field, or if they had been, they shied away from it like a fox from a baited trap. It has been our experience that the adjective "chemical" has a frightening effect on all but chemical engineers, particularly while they are students.

A sizable number of young engineers came to us looking for courses to help fill this void; men working in the petroleum industry who knew little or nothing about fractionation and distillation equipment; men working as mechanical engineers for chemical concerns who needed to know about gas absorption; men working for steel fabricators who knew nothing about bubble plates or the function of the unit in which they were placed, and yet were supposed to design these units for fabrication. To assist these men, we decided to offer a course for non-chemical engineers to cover the field of unit operations.

As these men were all graduate engineers, the course was given on a graduate level. It was not our intent to make chemical engineers out of mechanicals, but rather to acquaint them with the language and methods of unit operations so they could work more effectively with chemical engineers.

The course required forty-eight hours of instruction and was offered to a group of fifteen students in the Fall Semester of 1951–52. In the following sections we will outline the teaching objectives, subject matter covered, and give our evaluation of this initial course.

We would like to acknowledge the invaluable assistance given by some of the original students in pin-pointing many of the strong and weak points discussed.

Teaching Objectives

The specific objectives of the course were:

1) To teach the principles of the various unit operations, which amounts to semi-quantitative consideration of some phases of physical chemistry.
2) To focus attention on the application of energy and material balances to the design of unit operations such

as fluid flow, evaporation, and distillation, and

3) To emphasize the economic factors involved in process engineering by means of practical problems.

Subject Matter

The following is an outline of the subjects considered in this first course:

I. Introduction
  A. Definition of Unit Operations
  B. Examples
II. Fundamental Concepts
  A. General Approaches to Unit Operations
    1. Material Balance
    2. Energy Balance
    3. Equilibrium Concept (Dynamic)
    4. Rate Concept
  B. Basic Definitions and Laws
    1. Definitions of Chemical Terms (Mol, Chemical Formula, equations, Mol Fraction, Mol Volume)
    2. Gas Laws (Ideal Gas, Dalton's Law)
III. Flow of Fluids
  A. Pipes and Fittings
    1. Types and Uses of Pipes
    2. Pipe Layout Design and Cost Estimating
  B. Energy Relations
    1. Energy Balance Equations (General)
    2. Dimensional Analysis and Resistance Concept
    3. Design Problems
  C. Measurement of Flow Rates
  D. Pumping and Compressing
IV. Heat Transmission
  A. Conduction
  B. Convection (Emphasis on Calculations of Heat Transfer Coefficients)
  C. Radiation
  D. Heat Exchanger Design
V. Evaporation
  A. Background (Definition and Examples)
  B. Types of Equipment
  C. Physical Principles
    1. Boiling Point
      a) Defined
      b) Vapor pressure
      c) Effect of temperature
      d) Non-volatile solutes
      e) Effect of total pressure
    2. Boiling Point Rise Charts
  D. Evaporator Design (Economic Number of Effects, Method of Feed)
IV. Gas Absorption
  A. Background
  B. Type of Equipment
  C. Physical Principles of Gas Absorption
    1. Steady State Conditions
    2. Solubility Equilibrium
    3. Rate of Absorption
    4. Two Film Theory
    5. Mass Transfer Coefficients
  D. Absorption Tower Design
    1. Material Balance
    2. Rate Equation Integration (Tower Volume Determination)
    3. Transfer Units
    4. Channeling, Flooding
    5. Problems
VII. Distillation
  A. Background
  B. Types of Equipment
  C. Physical Principles of Distillation
    1. Scope of Study
    2. Ideal Solutions
    3. Raoult's Law
    4. Boiling Point Diagrams
    5. Composition Diagram (Constant Pressure)
VIII. Plate Calculations—Binary Systems
  A. Definition of Theoretical Plate —McCabe-Theile Method for Calculation of Number of Theoretical Plates in a Fractioning Column
  B. Optimum and Minimum Reflux Ratio
  C. Plate Efficiency
IX. Mechanical Features of Fractionating Tower Design

A. Vapor Velocity
B. Liquid Velocity
C. Principles of Design of Risers, Downspouts, and Bubble Caps

Evaluation and Recommendations

To determine the subject matter which should be included in a course of this nature cannot be done in a single step. After once presenting the course, it was decided to attempt to discover its deficiencies by means of a questionnaire filled out, anonomously, by the students.

In addition to the questionnaire, the results of short examinations, outside problem solutions, and informal comments by students aided in evaluation of this course.

From this information was gleaned the answers to three questions; first, how well the subject information was absorbed; second, what the student felt was needed in the way of previous study or preparation; and third, to what extent the course filled the students' requirements. A fourth question was answered by inference, that of how good a preparation the student had for the course material.

The answers to the above questions led to one very definite conclusion. The normal undergraduate training received in mechanical engineering tends to minimize, and even neglect, a basic understanding of chemistry and its applications. Even the psychological attitude of most mechanical engineers is against chemistry in all forms, as can be well realized by those who have labored to get across an understanding of combustion to undergraduates in thermodynamics and heat power. There is a definite need to create a respect, and to a greater extent an appreciation, of applied chemistry.

It was obvious from the result of that part of the survey to determine subject absorption that this basic training deficiency was present. Those subjects which depended upon basic understanding of material closely allied to mechanical engineering were well taken, while those based on knowledge of physical chemical principles were not absorbed as well.

It will therefore be necessary to add to the course a study of chemical process calculations. This must be done in such a way that an interest in the general subject is aroused by eliminating the vague generalities and associating the subjects to specific problems in which the student has a basic interest.

All of the students seemed to have some desires to cover additional unit processes which time did not permit in this course. This fact, coupled with the need for more introductory material, seems to indicate that six semester hours, or possibly even nine, will be needed to present Unit Operations to men trained as other than chemical engineers.

In considering the problem of covering all the subject matter desired, two possibilities present themselves. The one is to condense the time allotted to each individual operation; the other is to extend the course to six semester hours in length. Of the two, we feel the latter is more desirable.

To condense any of the material covered would mean that many subjects would only be superficially studied. This would leave a serious void, and not accomplish the primary purpose of the course. If the course were extended, all material, introductory in nature, could be sufficiently covered and enough time could be spent on each unit operation to allow sufficient discussion and problem solution to give complete coverage. Then, if the demand for more thorough familiarization arises, still another three hours could be used in the solution of actual or simulated plant design problems, keeping in mind that the mechanical aspects of the problem are paramount.

In spite of our limited experience with this course, we recommend that serious consideration be given by engineering schools to the idea of a unit operations option, either on the undergraduate or graduate level. We believe that this will increase the stature of the mechanical engineer in process industries and result in improved efficiency of process operations.

A Mathematics Foundation for Industrial Engineering*

By HOWARD P. EMERSON

Professor and Head of Industrial Engineering, University of Tennessee

Engineering has always been built on a foundation of mathematics and the basic sciences.

The trend today is toward greater use of mathematics. The Committee on Adequacy and Standards of Engineering Education of ASEE recently concluded that "the greatest potential for future development in science and technology is to be found in mathematics."[1] Engineering fields other than Industrial Engineering are finding growing need for a better foundation in mathematics and for mathematical courses higher than calculus.

For example, in the Southeast, curricula are beginning to be influenced by three big projects: atomic energy development at Oak Ridge, the Arnold Engineering Development Center at Tullahoma, Tennessee, and TVA with its regional electric power system. All of these projects maintain teaching or research relationships with the engineering colleges of the Southeast. The mechanical engineers are finding a need for higher mathematics for wind tunnel and jet propulsion calculations, the chemical engineers need higher mathematical analysis for atomic reactor design, and the electrical engineers have long required courses in differential equations since rates of change dominate their fields of study.

What about the industrial engineers? Do I. E. students already get enough mathematics or will Industrial Engineering follow the path of other engineering fields which also started with practical, rule-of-thumb methods but have become more and more dependent upon mathematics?

This program today on "Mathematical Analysis in Industrial Engineering" is intended to explore this question. In preparation for it one of the participants made a significant discovery—that it was hard to find industrial engineering applications of general mathematics, other than arithmetic and algebra, but further that there are "few applications of mathematics to industrial engineering problems that do not involve some aspects of statistics."

This discovery raises two points for consideration:

1. What present or future industrial engineering problems require mathematics in their solution and what are the mathematical techniques which the industrial engineer needs to solve them?

2. If most of the applications of mathematics are found to involve some aspects of statistics, is not this the logical field of specialization for Industrial Engineering?

Mathematics Courses Needed

Most of the conventional mathematical techniques, with the exception of statistical mathematics, are probably included in what I. E. students get now. At least this is what we found at the University of Tennessee, where a recent review of mathematical requirements common to all en-

* ASEE Annual Meeting, Industrial Engineering Division, Dartmouth College, June 25, 1952.

[1] S. C. Hollister, C. S. Crouse, L. F. Grant, and M. D. Hooven, "Report of Committee on Adequacy and Standards of Engineering Education," *The Journal of Engineering Education*, 42: 249–254, January 1952.

gineering fields suggested that few new topics needed to be added in the existing subject matter. Our engineering faculty adopted a requirement, which goes into effect this fall, of 5 hours each quarter in mathematics for the first two years, a total of 30 instead of 24 quarter hours in a common unified course for all engineering students. This unified course starts with differential calculus in the second week of the freshman year and ends with a brief introduction to differential equations. It is hoped that this will answer the objection of all departments requiring advanced work in mathematics that poor preparation limits performance in higher mathematics courses.

On such an expanded two year mathematics foundation later courses can be added if they become desirable. What would be such higher courses for the industrial engineer? One might be matrix algebra, useful in solving simultaneous equations and reaching decisions on optimum situations involving many variables. Differential equations may not be necessary since most of those industrial engineering phenomena involving rates of change can be handled by integral calculus. In the new field of cybernetics, involving substitution of mechanical for human brains in the form of computing machines, the industrial engineer already uses IBM punch card equipment and automatic calculating machines of ten digits, and these may be adequate for some years to come. In another new field, operations research, statistical mathematics comes into play.

Statistical Mathematics

The major exception not covered adequately in the basic two year mathematics course for engineers is mathematical statistics. Engineers have lagged behind in using statistical methods. Nearly every other profession has made use of them. If Industrial Engineering follows the trend of other engineering fields in requiring advanced mathematics in undergraduate or graduate work, I believe its field of specialization will be that of mathematical statistics. Statistical methods have already opened up new opportunities. They have brought striking results in quality control. But control of quality is only the beginning of the applications of mathematical statistics to manufacturing and manufacturing research.

Furthermore, some of the older industrial engineering techniques themselves, such as time study and methods evaluation, can be improved by statistical analysis.

A Subcommittee on College Courses of the American Society for Quality Control recommends one year of basic and applied, mathematically sound, statistical courses (9 quarter hours) as the eventual goal for all engineers.[2]

On the basis of all of this I believe the industrial engineer should "latch on" to statistical mathematics as the most productive of the mathematical fields. The industrial engineer should become the leader in developing engineering applications of it.

If this is a logical conclusion, how should industrial engineering students get their training in statistical methods? All of us throughout the country have been trying out different ways to accomplish this.

Probability Theory in Basic Math Courses

One suggestion is to include more probability theory in the first two years of mathematics. The new unified math program which I mentioned will include not only work on the binomial theorem and the method of least squares for fitting data, but an introduction to probability and statistical methods including permutations, combinations, the normal probability curve and correlation. I believe an introduction to these topics will get around a road block which seems to delay students in grasping probability mathematics.

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[2] *Industrial Quality Control*, Vol. VI, No. 4, January 1950, pp. 27–30, "Statistics and Quality Control in Engineering Courses," Report of Subcommittee on College Courses, ASQC.

Statistics Courses for Engineers

There are three phases to this unique field of statistical mathematics:

1. *Applications* by industrial engineers in plants. (Setting up control charts, introducing sampling plans or procedures, designing plant experiments.)
2. *Statistical techniques* required for these applications (such as the normal distribution, Poisson table, correlation, t-test, F test, analysis of variance, Latin square).
3. The *mathematical basis* for these techniques (such as proofs of formulas, the derivation of the data in statistical tables, mathematical properties of the normal curve and the whole concept of probability).

In view of this three-dimensional aspect of statistics for engineers, it is a knotty problem to decide who should present this subject to the undergraduate. One position we can take at the start: the engineer should teach the applications of this or any other method in engineering. The use of statistics is simply one means to an end. Departments of statistics teach the statistical techniques, but do not purport to do more than indicate how the formulas and tables were derived. If we turn to the mathematics department, which engineering colleges have been accustomed to doing in other mathematical fields, we run into a number of problems. One is the problem which we have faced in calculus, that math departments sometimes seem to have little interest in practical examples and may confuse the student with mathematical procedures, proofs of theorems, and derivations of tables, losing the students' interest. In the case of statistics this is tragic for it is a fascinating new field for the engineer.

Problems of Presentation of Statistical Mathematics

A further problem in building this foundation of statistical mathematics for industrial engineers is the type of presentation. Should each formula or table be backed by rigid proof? This will indeed get into matrix theory and the geometry of hyperspace, for some of the proofs in the field of statistical mathematics are as difficult as they come. Industrial engineering students who take statistical mathematics will find it as high level work as the mechanical or electrical or chemical engineers face in the higher math courses which they may take. Mathematical statistics is not easy.

Finally, shouldn't we think of statistical mathematics, not as an area of specialization, but an integral part of common core mathematics?[3] It is needed especially by industrial engineers but is eventually to be of use to all engineers. I believe this is in line with recommendations of the ASQC.[4] Teaching of both mathematics and engineering will need to be reoriented.

With manifold applications of statistics ahead of us, would the engineer not be wise to turn to mathematics as the basic, first-hand source of the theory to be applied?

Conclusions

The answer to the question of how much mathematics the industrial engineer should have, and how to present it, depends upon our concept of the industrial engineer and the relative emphasis on basic science and mathematics vs. applications

I discussed this whole problem with a practicing industrial engineer in a metal working plant who came to us recently looking for graduates. He said, "Just teach them to add and multiply."

I next discussed it with a consulting industrial engineer who had recently returned from Europe, where he found that industrial engineers are beginning to use higher mathematics. He said, "I feel that the industrial engineer in the future will be using some of the computing machines and matrix algebra. I believe that he should have a thorough grounding in statistics which should be taken after he has completed his calculus and probably

[3] Everett Laitala, Correspondence dated June 4, 1952.

[4] ASQC Subcommittee, *op. cit.*

should take matrix algebra at the same time."

In the light of these conflicting comments this paper suggests the following conclusions, in summary:

1. Many opportunities exist for using mathematical analysis in Industrial Engineering. This can be confirmed by making a list of mathematical techniques, both in general and statistical fields, and in a parallel column present or potential applications of each in Industrial Engineering.

2. Most of us have failed to make full use of these mathematical methods, but Industrial Engineering is not the only field which suffers from this failure. One reason for the reluctance to use mathematics by student, teacher, and plant engineer is that thorough understanding of mathematical analysis and practice in its applications are not provided in undergraduate work.

3. It is not enough to make "mere translations from a literary form of expression into symbols, without any subsequent mathematical analysis."[5] Not only economists, to whom this quotation has reference, but also industrial engineers in handbook style do this in such expressions as:

$$R = Y + C + E + F + M + L + T.$$

4. In order to bring about greater use of mathematical analysis in Industrial Engineering a firmer foundation of mathematical training needs to be provided for beginning students. One solution may be more hours devoted to the present mathematical subject matter. Another may be the so-called "unified" approach, which is being presented and discussed in the Mathematics Division of this conference.[6]

5. As "A Mathematics Foundation for Industrial Engineering" this paper suggests that two years of fundamental mathematics, more complete and thorough than it is now given, can provide the industrial engineer with many techniques which he might be encouraged to use more than he does at present.

6. Expanded emphasis on fundamentals can also provide a solid foundation for advanced mathematics courses or study. If such advanced work is needed, the first promising new field for industrial engineers is that of statistics or mathematical statistics. Other new fields like matrix algebra and symbolic logic can be investigated by gifted students through choice of electives or thesis investigations.

[5] John Von Neumann, and Oskar Morgenstern, *Theory of Games and Economic Behavior*. Princeton: Princeton University Press, 1944.

[6] W. R. Van Voorhis, "An Integrated Approach to Basic Mathematics."

Are We Ready to Consider a Major Change in Policy?*

By W. S. EVANS

Professor of Civil Engineering, University of Maine

Engineering—An Art or a Science?

The one piece of legislation most often mentioned in educational circles is probably the Morrill Act. Since this Act was signed in 1862, I am going to start off by saying that ninety years ago, our fathers made possible for future generations a new kind of education. Although it is not necessary for me to tell you that the part of this plan in which we are most interested was labeled, "Mechanic Arts," I remind you of it to emphasize that the forerunner of Engineering Education was thought of as an art. Of course, engineering was in those days, and still is, a mixture of art and science; but just as we can all agree on this, so I think, we can all agree that the mixture, the ratio of the part attributable to art to the part attributable to science has changed.

As evidence of this it is found that from the structural standpoint, present day writers credit the discovery or creation of the various styles of ancient architecture, the Greek Doric and Ionic, the Roman Arch, the Gothic Vaulting, to their creators as artists not as scientists or engineers. While the results were engineering accomplishments, they were arrived at by intellectual and physical processes which characterize an art rather than a science. Of course the originators of these ancient styles of architecture were great architects and engineers but their accomplishments seem to have been derived from art, not science. Great strides had been made prior to the middle of the nineteenth century, but when the Morrill Act was signed, there was still a close linkage between the craftsman and engineering accomplishments. As examples of what I mean, study the old covered bridges of New England and the type of building construction which required four-feet thick walls. I once had a well-known bridge engineer explain to me how he could determine accurately the bearing power of a soil by the kind of imprint his heel made upon it. I have no doubt that he could, but it was through ability developed as an art and not through scientific deductions that he was able to make such decisions.

When Frank Lloyd Wright built the first modern home, the exterior of which was not determined by conventional appearance but by the interior demands based on a utilitarian use of space, he began to take the art out of architecture. It is worthy of note that while the types of architecture developed in the remote past are attributed to the great artists of the time, the modern skyscraper in all its many styles, in fact most of the modern developments in architecture, are attributed to the engineer. The point I wish to make is that while 2000 years ago a structure had to be created by a master much as painting was created or a statue was modeled, today design is based on fundamental principles and concepts which may be acquired by anyone who possesses the will to do so and the necessary mathematical background.

* Presented at the 60th Annual Meeting of ASEE, Dartmouth College, June 23, 1952.

Service is the Yardstick of Engineering Accomplishment

You may be wondering just what this has to do with our subject. We have been asked to investigate and evaluate our present engineering curricula. To investigate is difficult unless we know the purpose of our investigation and to evaluate is impossible without a standard of measure. Then we should first determine what we are to measure, second, establish a standard by which to measure it, and third, make such investigations as are necessary to apply the standard.

Rather than measure the success of our educational program as it affects the individual and the employer, let us consider its effectiveness as a service to the public. Let us consider such questions as "Is Civil Engineering as a science progressing satisfactorily?"; "Are the structures we build the safest and most economical possible with the men and materials available?

As answers I would like to present a few observations. Three years ago there was built on the University of Maine Campus two fairly large buildings with reinforced concrete frames. Today, in the third year of their use, bad cracks are opening up under the spandrel beams at the roof level. Why? Two years ago at Seattle, a representative of the Portland Cement Association, told this group that we were 20 years behind the times in what we were teaching in our Concrete Courses. That gentlemen, is why those buildings are cracking. We don't understand Reinforced Concrete Design as we should. At Seattle, when that statement was made, we, not all of us, but you and I, rose up and said we couldn't do any different as we had to teach design according to the present specifications, and now I remind you of the title of this paper, "Are We Ready for a Change?"

Last summer, while travelling from Pittsburgh to Harrisburg over the Pennsylvania Turnpike, the most extensive superhighway in the country, I counted ten repair crews working on the roads in each direction, 20 in all, replacing broken down slabs and I am told it has become worse since then. From one coast to the other we find roadways pumping mud, pavements beaten up and broken down. And why? There aren't enough engineers who understand the necessity for sufficient foundation under our highways and who possess the will to obtain such understanding. The men who will be in the key positions in our highway departments 20 years from now are in our institutions this year. Will they be the right men for the positions, unless we are willing to make a change?

Theoretical Analysis and Technical Development

I'd like to give more examples in more fields but time doesn't permit. I am going to take time to ask a few more questions.

Is it accident that many of the leading mathematicians and scientists in this country were foreign born? Of course you can answer that, in many cases, circumstances forced them to this country and we have educated some great scientists too, all of which is true. Then I would ask "Is it accident that most of the original work on prestressed concrete was done in Belgium and France?" But, you can say, shortage of materials forced its development and I would remind you that, having been shown its use, we don't seem to find it such a bad economy either.

No, these things have not occurred by accident. The pattern is too clear cut. The Europeans have excelled in originating those things which can be derived from a background of fundamental theory. The reason is clear. The philosophy of Engineering Education in Europe is based on theoretical treatment of problems in hand. Ours is based on a practical treatment. Again I ask "Are we ready for a change?"

Requirements Change

Through the wisdom of our legislators in 1862, our engineering schools were

founded as "Colleges of Mechanic Arts." This was just and proper but times have changed. Civil Engineering in 1862 consisted largely of surveying and bridge building, with the building of canals and dams next. The field was narrow, the students few, and the instructor would pass on his skills with ease and effectiveness, but we are working under a different set of rules in 1952.

The American Society of Civil Engineers lists 14 Technical Divisions. If we consider 12 functional divisions for each one of these technical divisions, then we get 168 different classifications. Actually there are many more. So we see that since 1862 Civil Engineering has broadened to fields unheard of at that time. In the meantime it has become much less of an art and much more of a science. I cannot feel that our curricula, our methods or our philosophy have changed in proportion.

Our Objectives Should Change

You may well ask just what I mean by a change in Policy. I'm not sure I can explain it in a few moments, but I can try.

Let's start with Soil Mechanics. It was my fortune some thirty-four years ago to be subjected to a course in Foundations. As I remember the study consisted of a very rough classification of soils and a prolonged study of existing structures and their behavior. This was a common procedure, but Soil Mechanics as a science could never have developed from this kind of a foundation. When a scientist, properly trained, undertook to find out what happens to a particle of soil subjected to stress, Soil Mechanics, as a science, began to develop and it couldn't have developed any other way.

If we ever hope to design concrete structures on anything approaching a scientific basis, we must study the particles of concrete and their behavior from the time the mass is placed until it has been subjected to service for a period of years. In much of our structures work, the student gets the idea that he is studying specific structures rather than fundamental principles of stress analysis. It seems that in many cases we actually teach a few isolated applications instead of fundamental theory applicable to a broad field.

The change I am talking about requires no radical changes in our methods or curricula but it would require a change in our objectives and attitudes toward what is expected of a man with the B.S. degree. The young graduate should not expect $5000 for his first year's work and his employer should expect to offer a longer period of training and less immediate returns. In brief, we should hold the four-year curriculum for those things which can best be taught in the atmosphere of an institution of higher learning. We might adopt some such motto as "The Sciences for the student, the Arts for the practitioner." We must ever strive to increase the ratio of science to art in our engineering work and thereby continually whittle down on the factor of ignorance. This will require a change in our philosophy.

Are we ready to face that change?

The Role of the Instructional Staff in Extension Development

By M. D. ADAMS

Assistant Professor of Physics, Purdue University

Campus and Extension Relationship

Insofar as the program of the Extension is a duplicate of existing campus functions, adequate machinery and controls are available through the existing Departments of the University and administrative organization. Purdue University has been extremely wise in extending intact these time-tested controls to similar off-campus activities. It is not the purpose of this analysis to question this existing organization or its adequacy to do off-campus the same job that it does on-campus.

But the Extensions represent a pioneering movement, in a sense, into new fields and heretofore undeveloped phases of technical education. There are consequently problems associated with them which are not shared by the campus organization but are unique with the Extensions. For the solution of these special problems, the campus-directed organization alone cannot do the job that progress and the urgency of "today" demand.

Some Extension Problems

What are these specialized problems growing out of specialized functions?

Very briefly summarized, the basic facts and conditions concerning the Extension Program which differentiate it and its problems from the campus program are these:

1. Extension students usually live at home with the attendant advantages in economical living but disadvantages of transportation, disturbing home influences on study, and absence of many campus cultural influences and developing experiences.

2. Extension students are combining "Earning and Learning" to a far greater extent than are campus students, and have the accompanying problems of time-budgeting, overwork, and health hazards.

3. Much of the program of the Extension falls into the classification of adult education with its part-time, older night students. This necessitates a wide departure from the formal and traditional classroom methods to those better adapted to adult education.

4. In the college-credit classes, more and more students of border-line ability-level are using the Extension for a "try-out" period. The result is more stringent demands in the field of guidance and a greater premium on instruction and instructional effort than with the higher-ability average of students on the campus.

5. The terminal two- and three-year programs of the Technical Institute are exclusively specialized Extension activities with all of the attendant problems of working in a new field in close cooperation with local industries whose needs the program serves.

Some Conclusions

From such a hasty sketch, what should be our conclusions?

Over-all generalizations are difficult to make, but this Extension program clearly implies that some of its greatest assets will be:

1. Flexibility, sensitivity for, and close coupling to community needs.

2. An atmosphere of genuine interest, and wholehearted helpfulness in guidance and learning processes.

3. Over and above all, a very high caliber of instruction, based on mastery of subject material, knowledge of teaching techniques, and understanding of students and their individual needs.

4. Facilities for making this program effective.

All of the adequate adaptations and adjustments needed to bring the operative program more closely into line with the above goals and objectives of the Extension cannot be made, with complete success, by long range from campus offices but must be made largely on the front lines by front-line operatives. Such adjustments can only be achieved gradually through the years by responsible, wholeheartedly interested, pioneering staff members wrestling daily with their very real front-line problems. Without utilizing the initiative and originality of these active instructional staff members, the Extension will never take on that distinctive character that it must assume if it is to survive and meet its highly specialized objectives and obligations.

Neither will it be sufficient to staff the Extension with energetic, ambitious, and far-seeing administrators who have the vision to understand the role of such an institution in the community, if that administration acts on the principle that adequate progress can be accomplished by "executive edict" from the top down. Certain achievements may ensue from such controls, but cooperative team work between the entire staff *on the job* can alone attain the highest goals. Far worse would be the situation if any Extension should ever become tied down to men of small administrative stature to whom the instructional staff would look in vain for the constructive leadership so essential in any cooperative endeavor.

Some Suggestions

How best, then, can the cooperative efforts of the entire staff be directed and guided to achieve these common, desirable, specialized goals of the Extension?

Before constructive, cooperative work can be achieved, correct attitude and morale among staff members toward the entire program of the Extension must be secured. Somehow there must be engendered in each member a feeling of personal and group pride in the work being done. Little progress can be made as a group until each person accepts the responsibility, not only of doing his own specific work well, but of promoting the common welfare of the Extension wherever possible.

If the work of the staff is to be properly coordinated, it cannot be sporadic or unorganized. Concerted group action can only function where responsibility and authority are clearly defined, understood, and generally accepted.

Of course, it is possible for a staff to mire itself down in the maze of its own organization with a multitude of nominal committees and officers whose functions are poorly understood, whose authority and responsibility are undefined or at best hazy. It is of utmost importance that the administrative and instructional staff mutually define, or re-define, and establish these relations so clearly and openly that no doubt can exist, or the feeling ever prevail that where the program fails it is "your" failure, but where it succeeds it is "my" success. Where authority is needed, it must be clearly granted and the accompanying responsibility accepted. Where decisions are to be made within the province of the staff, they must be made only in the democratic manner by the groups concerned.

Attitude, however good, and organization, however efficient, do not of themselves alone guarantee sound development of the Extension. The staff will never be capable of doing the required constructive thinking, planning, and deciding unless thoroughly and painstakingly fortified with all available knowledge and facts pertaining to the Extension at all times. The staff must be supplied with all of the information available as soon as it be-

comes available. This cannot be left to chance, or the "grapevine" but must be supplied by definite, well-planned channels.

A mimeographed news bulletin published weekly through the cooperative effort of administration and staff would appear to be of value and to be recommended. More bulletin material on a large bulletin board available only to the staff might be utilized. Not only is basic information about courses, classes, hours, objectives, etc., necessary to the staff for constructive thinking, but also every staff member is and should be more or less a public relations agent for the school wherever he may go in the community. He can function in this capacity only to the extent that he is well informed.

The effect on staff attitude and morale in being in "On the Know" is great; because with this sharing of the knowledge and plans comes the feeling, "This is MY school. I am a vital part. I am not a mere observer or passive employee. My achievements are given fair recognition."

While the problems in the various departments may vary widely, there are still many problems common to all Departments and all staff members of the Extension. It is important that these problems be faced cooperatively by the staff. A definite schedule of professional meetings devoted to planned exchange of ideas and experiences on these specialized common problems should be a vital part of the yearly plans of operation. The content of such meetings would be both inspirational and informative in character. These discussions would serve the double purpose of informing and at the same time welding the staff into a genuine professional group, understanding and working together to achieve common objectives. Such meetings are not to be confused with administrative meetings held at rare intervals for clarifying administrative details only.

Orientation Meetings

The specialized objectives of the Extension are such as to place superior instruction at a high premium. This should be one field in which the smaller Extension located in its own geographically small community, with closely integrated staff, should be able to excel the campus organization. Circumstances, however, make it necessary to utilize instructors who have not always been well prepared in the "art" of superior instruction. Especially is this so with the many part-time instructors from industry who, in some cases, have had no previous experience in teaching although well grounded in their own specialized fields of knowledge and skills. Therefore, it would appear to be advisable that in addition to the professional meetings mentioned above that there should be carefully planned orientation meetings for new instructors and part-time instructors. These meetings could well be planned for weekly intervals covering from one to two semesters. Attendance and participation could be made a part of the teaching contract. If the supply of potential instructors in the community were large enough to justify it, there might come a time when attendance at such a series of meetings could be made into a prerequisite for employment later and thus build up in the community a "backlog" of properly or partially oriented and trained instructors in various fields for part-time or even full-time employment. The content of such meetings would include not only instruction in the basic objectives of the school and the administrative details of operation, but carefully planned and functional instruction in the art and techniques of good teaching.

This orientation program would utilize instruction that is now available at most of the centers in the form of key instructors who have demonstrated themselves to be superior teachers. There is no reason to believe that such added duties would be an additional burden. They should be part of the regular teaching load of the key instructors. To most teachers, such selection would come as an honor and a personal challenge to increase further their service to the institution and to their students.

Associated with this in-service training is recommended closer cooperative supervision of the actual conduct of class instruction. The nature of the instruction that takes place is so vital to the institution that every opportunity for improving and maintaining the best must be utilized. A few poor spots in instruction, as well as a few rare cases of perniciously poor practices and attitudes, may do more harm to the entire program than a far greater number of superior instructors could offset. Cases of poor teaching practices must be eliminated through constructive supervision plus the united pressure of faculty group-opinion to attain excellence of instruction.

Dual Nature

The administration and direction of the Extension are made doubly difficult by the dual nature of the program—College Credit and Technical Institute. Misunderstandings between these programs in some cases have apparently worked against the best interest of the entire Extension. There is, of course, no fundamental conflict between the two sets of objectives as they almost perfectly complement each other. But artificial barriers may arise and even be magnified into important obstacles to progress, if certain pitfalls are not avoided.

In a few cases there may have been a feeling between these two groups that there is a difference in prestige, a difference in the fundamental worth and soundness of the two programs. Such a conception, of course, disappears when a sound general philosophy of Technical Education as a whole is developed. The feeling that one program can grow only at the expense of disregarding or sabotaging the other is not well founded. To avoid and to eliminate this feeling become the direct responsibility of teaching and administrative staff. Inasmuch as the objectives are so different, the instructional problems and procedures must differ widely. This difference automatically eliminates much overlapping of staff functions—teaching in both programs. But where overlapping instruction is possible, without detriment to either program, it is heartily advocated for its unifying influence. There has existed an attitude on the part of some that one program is to grow and develop—the other to deteriorate to extinction. This attitude, while not based on sound fact, is deplorable in the effect it produces in disrupting proper coordination and cooperation and in undermining staff morale.

Cooperative Teamwork

A University teaching staff is not like unto a group of day laborers who do their cut-out work, perform the bidding of the boss, draw their pay, and go home. They are high-calibre men and women who think as they work, who are fully capable and qualified to contribute the fruits of their thought to the betterment of the school, if given an opportunity to do so. For administrative officers to ignore this in thought or deed, intentionally or not, is to throw away a tremendous asset of the school. For the administration alone, at any level, to set up any unique Extension policy and "spring" it in "edict" fashion on the staff is a most unwise procedure. The average staff member is fully capable of giving very sound consideration and counsel on all problems intimately associated with the Extension's progress, and if his whole-hearted cooperation is to be secured, opportunity for this must be provided and major policies projected only after a majority of the staff has become convinced of the soundness of the change and has been enlisted whole-heartedly in its support.

Here, as in so many other of our American institutions, the ultimately greatest dividends come only as the result of cooperative teamwork.

Some Thoughts on the Purpose of a College Education*

By ROBERT S. ROWE

Associate Professor of Civil Engineering, Princeton University

Have you ever stopped to ask yourself the purpose of a college education? Is it to obtain knowledge? Is it to insure a job? Or is it to guarantee wealth and success?

Have no illusions. Of the vast amount of knowledge available, a student is exposed to a very small amount, and two years after graduation he has forgotten much of that. An education is an opportunity and does not guarantee anything. You get out just what you put in —no more, no less. It is true that if you have been adequately educated, you will have the tools which will enable you to compete with men from other institutions; and if you are fortunate, you may gain wealth and success. But what is an adequate education?

An adequate education depends upon three things: the understanding of fundamental concepts; the desire to seek the truth; and the ability to ask questions.

It is essential that you know the fundamental concepts which pertain to the basic subjects that interest you, and perhaps a few fundamentals pertaining to unrelated subjects. A good teacher will present the fundamental concepts. But there are relatively few good teachers. It may be that you are forced to dig the fundamentals out for yourself. Perhaps you will be inspired in such a way that digging becomes a challenge. The understanding of a few fundamentals is much more valuable than a large amount of unclassified knowledge.

One of the important aims of a college education is to teach you to seek the truth. You are taught not to accept written matter blindly, but rather to understand what you read so that you may determine what is true. It is often difficult to be truthful with yourself. If you do not know the answer to a question, you are shown that there is merit in working out the solution for yourself. You gain nothing by relying on someone else's ability. Of course, it is easier to coast downstream (let someone else do your thinking for you) than to pull up against the current (think for yourself). In one case you cover a lot of ground, but gain nothing; in the other case, you cover less ground, but profit immeasurably.

And closely related to seeking the truth is the ability to ask questions. It is not difficult to find someone to answer questions. There are many who prefer to use their instructor as a slot machine: put in the question, turn the crank, and obtain the answer. But this method does not help them one bit. The important thing is to ask questions of yourself which will lead you to the solution. What is the fundamental upon which this is based? Is this or that true? Why? Is there another way of doing this? How? . . . ad infinitum. By asking questions and thinking things out for yourself, you will obtain a better understanding of any problem.

A college education, then, is nothing more than an opportunity where each individual is entirely responsible for his own attainments. The possibilities for learning are unlimited. The synthesis depends upon the understanding of fundamental concepts, the desire to seek the truth, and the ability to ask questions.

Acknowledgments. The ideas expressed herein have been influenced by the writing of George Fillmore Swain and the teaching of Hardy Cross.

* Written at the request of a group of students.

International Conference on Engineering Education—London, January 12–17

The sessions of the International Committee on Engineering Education of the United States and Europe Council of Engineering Societies more commonly called EUSEC were the first on engineering education held in Europe. The hosts were the Institutions of Civil, Mechanical and Electrical Engineering of Great Britain.

While in North America the Colleges of Engineering have been organized for sixty years and are currently arranging their sixty-first Annual Meeting, no such unifying force has been at work in Western Europe and Great Britain.

EUSEC has had one previous conference devoted to Management, this in the Netherlands in 1951. The organization committee on Engineering Education was requested to present a review of existing patterns of engineering education and practice in each of the cooperating nations, then bring in recommendations or future cooperation between the EUSEC members in matters of engineering education and practice.

North America representation was made up of Col. L. F. Grant of Canada, Chairman of the Engineers' Council for Professional Development, Dean Thorndike Saville, Chairman of the E.C.P.D. Committee on Engineering College Accreditation, and Dean W. R. Woolrich, President of the American Society for Engineering Education. Three practicing engineers and engineering educators likewise represented the nations of Norway, Sweden, Denmark, Belgium, Netherlands, France, Switzerland, Italy and Great Britain.

The six days of sessions from January 12 to January 17 beginning daily at 10 A.M. and continuing usually to 10 P.M. ironed out many misunderstandings as to the status and education of engineers in the countries represented and there developed a greatly increased appreciation of each others problems as the meetings progressed. By the end of the sessions delegates were calling each other by their first names as if they had known each other from childhood.

The agenda for these days was divided into the following headings:

(a) The classes of educational establishments with courses leading to professional engineering qualifications, stating the number of establishments in each class.

(b) The number of students successfully completing the final examinations at the end of the courses in each of the classes in (a).

(c) The general educational requirements before a student may be admitted to a course of academic study in the classes in (a).

(d) Scope and broad extent of study in the following subjects in each of the classes in (a):
Basic Science
Applied Science
Technological Applications

(e) Method of examination and the nature of the award granted on the conclusion of the studies in each of the classes given in (a).

(f) Scope of nature of practical training and subsequent experience required for professional qualification.

Several weeks of preparation for each nation's team was given over to the preparation of papers on the history and procedures of engineering education and rec-

ognition. Preprints of these reports were available to each of the delegates prior to the convening of the conference.

Considerable time was devoted to definitions of educational and engineering terms which have widely different meanings in the countries represented. For example a "College of Technology" suggests an institution that offers a Bachelor of Science degree in North America but in Great Britain it more commonly indicates an institution giving a wide range of day and evening courses in cooperation with industry mostly on the trade school level, while in Belgium it would have a still lower level of academic rating. It is quite evident that the development of a standard international terminology for engineering education is a desirable goal to pursue.

With the annual influx of some three thousand graduate students coming into the United States for advanced work and when we recognize that a large number of these intend to take graduate level courses in engineering, then we can more fully appreciate that the Universities and Colleges of Engineering of the United States have a very great interest in the minimum standards, the quality and the philosophy of engineering education beyond the Atlantic.

We have much to give Great Britain and Western Europe from our sixty years of experience in engineering education study and analysis, but in turn we have much to learn from their many patterns of engineering education which have been especially designed to meet highly industrialized regions.

Those of us who spent the five or six days in continuous conference together at these preliminary sessions were convinced that similar biennial sessions would be of great value in raising the quality and effectiveness in engineering education in all of the eleven countries represented.

In both war and peace the professional engineer must carry on major responsibility for the industrial economics, the scientific advancement and the management accomplishment of each of the nations represented. The success of any Atlantic confederation must necessarily rely very largely on the cooperation of its scientific and engineering personnel.

The sessions concluded by recommending to EUSEC that biennially similar sessions be convened and that the next conference be held in one of the European countries September 27 to October 2, 1954 with interim working committees designated to preparing reports on those educational problems that are of special international interest and concern to professional engineers. The Proceedings of the Organization Conferences will be available within a few weeks from Great Britain.

1953 ASEE-GE Teaching Methods Seminar

For the second consecutive year the General Electric Company is joining with the American Society for Engineering Education in sponsorship of a seminar on "Teaching Methods in the Advanced Engineering Program." The 1953 seminar will be held in Schenectady, New York, from June 15–20.

The operation of the seminar will be somewhat similar to last year's as recommended by Messrs. B. R. Teare, Jr. and K. B. McEachron, Jr. in the *Journal of Engineering Education,* January 1953. The present plans will include the application of some of the newer techniques, such as the use of a creative approach to the solution of a professional type engineering problem. Below is a rough sketch of the operation of this year's seminar.

Again, each portion of the seminar will have two phases. The first is the demonstration of a teaching technique as used in the Advanced Engineering Program, and the second is the application of the technique to college teaching.

One of the major pillars of teaching philosophy in the Advanced Engineering Program is "learning by doing." The seminar therefore will teach the problem-solving method of learning, by using the method itself. Actual problems will be worked by the seminar members and as much as possible of the atmosphere between the instructor and the student as used in the Advanced Engineering Program will be maintained. Most all A.E.P. lectures have evolved toward discussion periods with active participation by all present.

The problems which will be assigned will be typical of problems encountered in the Program, but somewhat shortened to use more efficiently the time available. Most Program problems are of an analytical nature and are designed to emphasize the firm foundation of understanding of a principle involved. Each of proposed problems for the seminar will require some time for solution, with the beneficial accompanying evaluation and discussion. Combined with the actual solution, the discussion soon after submission of the results firmly implants the material covered. The seminar will include evening sessions as well as morning and afternoon.

Perhaps the largest benefit that the seminar members will receive will be through the free interplay of thoughts and ideas that flow between the participants. All members of the seminar will be housed in a single fraternity house on the campus of Union College in Schenectady. Thus housing and dining will be arranged to stimulate and maximize discussion.

Certainly not all of the Advanced Engineering Program is profitably spent in concentrated problem solution. Saturation of learning seems to occur if extra-curricular breaks are not included. The seminar members will likewise include breaks for an "entrance exam," a smoker, and a "graduation banquet." A tour of sections of the Schenectady Works and Knolls Research Laboratory in addition to conferences with engineers prominent in a given field will probably be arranged.

Staff members representing most accredited colleges (Electrical or Mechanical curricula) have been contacted and asked to submit candidates for seminar membership. On the basis of providing a geographical and curriculum-wise distribution of members, 25 individual candidates will be invited to attend.

All expenses including transportation for the members will be borne by the General Electric Company.

Any further information concerning the 1953 ASEE–GE Seminar on Teaching Methods may be obtained from the Advanced Engineering Program, General Electric Company, Schenectady 5, New York.

Discussion on "A Philosophy of Graphics"

By JOHN SCOTT CAMPBELL

Instructor in Electrical and Mechanical Engineering, California Institute of Technology

John Rule's recent paper on "A Philosophy of Graphics" should serve as a stimulus for all of us who teach this old and honorable subject. It should make us ask ourselves the question: Just what is graphics, and what can it do for the student in science and engineering toward the furtherance of his career?

There are many ways of looking at graphics. Like the blind man making a Braille examination of the elephant, it depends very much upon our viewpoint. From the standpoint of the engineering draftsman, it is a language by means of which the engineer communicates his design ideas to other engineers and to the man in the shop. A little better version of this viewpoint makes graphics the means for design itself, whereby the layout man clarifies his own original ideas by getting them down on paper. Those of us who advocate a touch of freehand drawing see graphics as a way to sharpen up the student's powers of observation, and to improve his ability to visualize in three dimensions. Descriptive geometry looms large in any graphics course both as a practical method of solution to knotty geometrical problems, and for its value in improving abstract visualization. Less emphasized now is the solution of problems by graphical construction: all the old straightedge and compass constructions that produce such pretty designs, but which also at times are very useful. And still occupying an uncertain position in graphics is the whole field of representation of data by graphs, ternary diagrams and the like, and the field of graphical calculation by function scales and nomographic charts.

Now this may seem like a large and helter-skelter collection of topics relating to graphics. What is needed, perhaps, is a unifying viewpoint to tie it all down and put the loose parts in their proper places. Professor Rule's discussion goes far toward supplying such a viewpoint. I would like to venture forth with another thought, for what it may be worth.

The activities of both scientists and engineers may be classified broadly into three phases: The collection of data; its analysis and reduction to usable form; and its application in the solution of problems. These divisions are not sharp, but rather lie upon a continuous scale. The thinking of an individual scientist or engineer ranges back and forth along this scale constantly, and, indeed, one mark of a good scientist or engineer may be the ability to be equally at home on all parts of the scale. In general, however, we may say that the scientists live mostly near the "data collection end" whereas the engineers are generally congregated at "applications."

Both must spend time in the middle, however, where the important job of reduction and interpretation is performed. Now let us inquire for a moment just what happens in this central region of our scale. A great deal of data reduction and problem solving is done by straight intuitive reasoning. But long ago it was found that the intuitive ability of the human mind has its limits, and so a system of symbols was devised for recording quantitative data, and rules developed to manipulate and transform data without the introduction of distortion, in order to present it in a more appealing and understandable way to the mind. From the viewpoint here being developed, this is mathematics. At the same time the scientists discovered that the most convenient

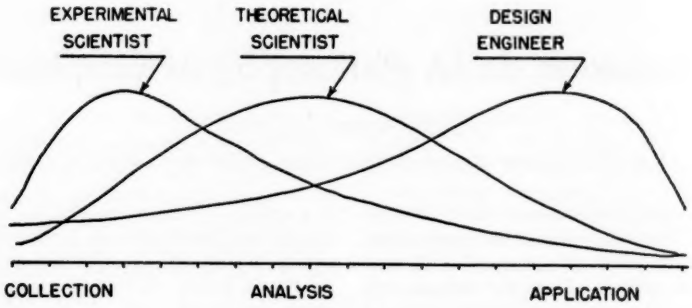

FIG. 1.

ways of measuring things did not always yield results which were easy to visualize and hold in mental contemplation. And so new concepts were invented, like energy, inductance and entropy which are not obviously present in nature to be sensed, but which seem to appeal to the mind in the sorting and comparing which makes up problem solving.

Appeal to our Senses

It is about here that graphics comes finally into this discussion. For the process of clarifying understanding logically starts with an appeal to our senses, of which the visual is most important. So I submit that graphics is, first a way of converting ideas into visual form so that they may be taken into the brain by the great main channel of communication with the outside world, the eye. To do this we employ pictorial devices to represent physical quantities: bar graphs, curves, positions on function scales and in the areas of charts, tone gradation, colors, the concept of contours of equal value and three dimensional models.

I believe that we have hardly scratched the surface of graphics, viewed in this way. For this is more than a means to an end: it goes into the most intimate processes of thought and determines the very shape and texture of the idea which we examine, rework and finally turn out as a solution. How often is our trouble caused by "not quite seeing it the right way"—and how often has the solution been unexpectedly smoothed by "A new viewpoint"? These old expressions are founded upon experience in a field which is essentially graphical—a field as old as man, and at the same time one offering exciting opportunities for new developments.

Professor Rule's remarks have opened the door to a whole new vista in graphics. A part of this view, I believe, is suggested by the foregoing brief discussion. There are many other aspects in this useful and interesting subject. I look forward to the further development of Professor Rule's philosophy of Graphics in the pages of ENGINEERING EDUCATION and other publications.

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny	West Virginia University	April 17–18, 1953	C. H. Cather, West Virginia University
Illinois-Indiana	Rose Polytechnic Institute	May, 16, 1953	H. A. Moench, Rose Polytechnic Institute
*Kansas-Nebraska	Kansas State College		M. H. Barnard, University of Nebraska
Michigan†	Detroit Institute of Technology	May 9, 1953	C. C. Winn, Detroit Institute of Technology
Middle Atlantic	University of Delaware	May 2, 1953	C. Bonilla, Columbia University
Missouri	Washington University	April 11, 1953	G. F. Branigan, University of Arkansas
National Capital Area	Howard University	May 9, 1953	L. K. Downing, Howard University
New England	University of Vermont	Oct. 10, 1953	E. T. Donovan, University of New Hampshire
North Midwest	Marquette University	Oct. 9–10, 1953	A. B. Drought, Marquette University
Ohio	University of Cincinnati	May 2, 1953	H. K. Justice, University of Cincinnati
Pacific Northwest	Washington State College	April 24–25, 1953	J. P. Spielman, Washington State College
Pacific Southwest	San Jose State College	Dec. 29–30, 1953	C. M. Duke, University of California at Los Angeles
Rocky Mountain	University of Colorado	April 11, 1953	C. A. Hutchinson, University of Colorado
*Southeastern	North Carolina State College		D. V. Terrell, University of Kentucky
Southwestern	University of New Mexico	April 3 & 4, 1953	M. L. Ray, University of Houston
Upper New York	Rochester Institute of Technology	October, 1953	F. E. Almstead, State University of New York

Members of the Society are welcome at all Section Meetings

*** No Date Set.**

TEACHING POSITIONS AVAILABLE

The following rules were adopted by the General Council of the ASEE:

1. The privilege of advertising for teaching positions is extended only to colleges and technical institutes which are either Active or Affiliate Institutional Members of the ASEE.

2. Advertisements must be for positions available only. No advertisements will be accepted for an individual seeking a job.

3. Advertisements should not specify salaries.

4. Advertisements must be submitted not later than the first day of the month preceding the month of issue.

5. Because of limited staff, the ASEE headquarters cannot maintain personnel files or supply detailed information about jobs. In replying to blind ads, address letters to American Society for Engineering Education, Northwestern University, Evanston, Illinois and give blind ad number.

6. Information and rates for advertising in the Journal can be received by writing ASEE Headquarters.

7. In order to conserve space and achieve uniformity, the privilege is reserved to rearrange advertisements.

BROWN UNIVERSITY HAS OPENings for Instructors and Research Assistants in the Fields of Electronics, Electrical Machinery, Experimental Stress Analysis, Mechanics of Solids, Mechanics of Fluids, Thermodynamics, Transonic and Supersonic Wind Tunnel Experimentation. Positions involve ½ time work and ¾ time study or ¾ time work and ½ time study leading toward M.S. or Ph.D. degree. Salaries for June graduates are adequate and account is taken of experience and special qualifications. Write to: D. C. Drucker, Chairman, Division of Engineering, Brown University, Providence 12, R. I.

UNIVERSITY OF CALIFORNIA, Berkeley. September, 1953. Appointments require teaching of basic courses to the field of specialization as well as advanced courses in the field. Research and development activities are expected of all staff members. *Civil Engineering:* Professor in Structural Engineering. Experience: Outstanding engineering practice, research and teaching, to qualify for directing and developing research in structural engineering and materials in addition to teaching graduate work. Associate Professors: 1 Engineering Materials, 1 Municipal Engineering. Education: Minimum, M.S. or equiv. Engineering degree. Experience: Minimum 10 years, should have considerable engineering practice or research and development experience in specialized field. Assistant Professors: 1 Soil Mechanics, 1 Structural, 1 Construction. Education: Minimum M.S. and two years research and development experience of Ph.D. Experience: Minimum 2 years including 1 year professional practice. *Mechanical Engineering:* Associate Professors: two, 1 in Heat Power Engineering and 1 in Metal Processing (resistance welding). Education: Minimum M.S. or equiv. Engineering degree and 2 years of research and development engineering experience in industry. Experience: Should have 2 to 3 years industrial experience and some teaching in engineering subjects at college level. Instructor: two, 1 Heat Power Engineering and 1 Hydraulic Structures. Education: Minimum Ph.D. degree or M.S. degree and 2 years of equiv. research and development engineering experience in industry. Experience: Minimum none, desirable 1 year part-time teaching experience in engineering laboratory courses. Apply to Dean of Engineering.

INSTRUCTOR OR ASSISTANT PROFessor of Civil Engineering with advanced degree, to teach Mechanics. Rank and salary dependent upon training and experience. Location, northern New York. Ap-1.

ASSISTANT PROFESSOR OF CIVIL Engineering. Major activity will be in the area of Surveying and Mapping for which a background of experience is desirable; salary open. Ap-2.

POSITION IN MECHANICAL ENGIneering, Location, New Orealns. Field of Machine Design, Kinematics, Mechanisms. A. M. Hill, Tulane University.

UNIVERSITY OF NOTRE DAME REquires teacher of Electrical Engineering, effective September, 1953; young man with doctorate and interest in servo-mechanism field preferred. Rank and Salary dependent on training and experience. Ap-3.

CIVIL INSTRUCTOR (9 mo.): MASter's Degree with some practical experience. Must be able to handle classes in Surveying, Fluid and Soil Mechanics, and Highways. Small university—Ohio. Economical living conditions. Ap-4.

ASSISTANT OR ASSOCIATE PROFESsor Mechanical Engineering: Duties, to instruct undergraduate students and develop post-graduate work. Time and facilities for research. Qualifications: University graduate, preferably some post-graduate training. Several years practical experience which may include industrial graduate engineer training course. Classification of appointee will depend upon qualifications of successful applicant—apply Nova Scotia Technical College, P. O. Box 1000, Halifax, Canada.

INSTRUCTOR IN MECHANICAL ENgineering to teach Thermodynamics and Analytical Mechanics Courses. Opportunity for graduate study. Apply to Prof. Alexander W. Luce, Pratt Institute, Brroklyn 5, N. Y.

ASSOCIATE PROFESSOR OF MEchanical Engineering to be responsible for Thermodynamics and Heat Power instruction including the laboratory. Opportunities for reseach or consulting work with local industry. Apply to Prof. Alexander W. Luce, Pratt Institute, Brooklyn 5, N. Y.

New Members

ADAMS, CLEVELAND L., Head, School of Textile Technology, Alabama Polytechnic Institute, Auburn, Ala. W. C. Knight, A. S. Chase.

ADAMS, MAURICE D., Assistant Professor of Physics, Purdue University, Lafayette, Ind. A. P. McDonald, G. Flake.

AXTELL, JOHN D., JR., Associate Research Engineer, University of California, Berkeley, Calif. A. M. Saunders, E. D. Howe.

BALDWIN, LEONARD B., JR., Assistant Professor of Civil Engineering, University of Idaho, Moscow, Idaho. J. T. Norgord, H. W. Silha.

BARTLETT, PAUL E., Coordinator of Engineering Classes, University of Colorado, Denver Extension, Denver, Colo. K. H. Stahl, C. A. Hutchinson.

BAUER, WALTER H., Professor of Chemistry, Rensselaer Polytechnic Institute, Troy, N. Y. A. B. Bronwell, W. R. Woolrich.

BEHLKE, CHARLES E., Assistant Professor of Civil Engineering, University of Alaska, College, Alaska. E. H. Beistline, E. F. Rice.

BROWN, CHESTER R., Assistant Professor of Industrial Arts, University of New Mexico, Albuquerque, N. M. C. T. Grace, R. J. Foss.

BUER, HOWARD H., Assistant Professor in Civil Engineering, University of Delaware, Newark, Del. D. A. Arm, H. S. Bueche.

CARNEY, CHARLES J., Jr., Managing Director, Society of Industrial Packaging and Materials Handling Engineers, Chicago, Ill. N. A. Parker, L. A. Rose.

CASHEN, WILLIAM R., Professor of Mathematics, University of Alaska, College, Alaska. E. H. Beistline, E. F. Rice.

COMER, JOHN W., Associate Professor of Civil Engineering, Oklahoma A. & M. College, Stillwater, Okla. D. M. MacAlpine, B. M. Aldrich.

CUMMINGS, MARY H., Assistant Professor of Mathematics, University of Rhode Island, Kingston, R. I. E. M. Pease, J. R. K. Stauffer.

DAWSON, EDWARD, Professor of Engineering Research, Pennsylvania State College, State College, Pa. E. A. Walker, E. B. Stavely.

D'AZZO, JOHN J., Associate Professor of Electrical Engineering, USAF Institute of Technology, Dayton, Ohio. C. H. Houpis, W. J. Price.

DELUISE, FRANK J., Research Assistant-Experiment Station, University of Rhode Island, Kingston, R. I. H. Campbell, D. Bradbury.

DEMARSE, JENE E., Instructor in Engineering Graphics, University of Maine, Orono, Me. M. McCleary, A. S. Campbell.

DEONIK, WALTER A., Instructor in Engineering Drawing, Case Institute of Technology, Cleveland, Ohio. O. M. Stone, A. M. Belavic.

DOBBINS, CECIL L., Business Coordinator, Fenn College, Cleveland, Ohio. M. B. Robinson, D. C. Fabel.

ENSLOW, RIDLEY M., JR., Assistant Manager, Tech. Book Dept., The Macmillan Co., New York 11, N. Y. C. L. Skelley, A. B. Bronwell.

FISHER, C. JOE, Head, Refrigeration Dept., Oklahoma A. & M. College, Stillwater, Okla. H. P. Adams, H. Lineback.

HASSLACHER, GEORGE J., III, Instructor in Engineering Mechanics, Pennsylvania State College, State College, Pa. J. W. Breneman, R. K. Vierck.

HERBEIN, HAROLD J., Assistant Professor of Engineering, Pennsylvania State College, State College, Pa. T. S. Rung, V. E. Neilly.

HILL, W. SCOTT, Manager, Technical Recruiting, General Electric Co., Schenectady, N. Y. M. M. Boring, D. S. Roberts.

HOLROYD, HOWARD B., Associate Professor of Mechanical Engineering, Iowa State College, Ames, Iowa. H. M. Black, H. J. Stoever.

HOSTETTER, ABRAM E., Professor, Shop Practice, Kansas State College, Manhattan, Kans. R. C. Potter, M. A. Durland.

JENKINS, RAYMOND E., Associate Professor of Mechanical Engineering, Southwestern Louisiana Institute, Lafayette, La. F. W. zur Burg, P. A. Chieri.

KALISH, AIDA, Instructor in Mathematics, Polytechnic Institute of Brooklyn, Brooklyn, N. Y. E. Hausmann, H. S. Rogers.

KERR, HUGH B., Assistant Professor of Mechanical Engineering, University of Alabama, Tuscaloosa, Ala. G. H. Backer, H. Kuengel.

KROMP, CARL M., Assistant Professor of Industrial Engineering, University of Florida, Gainesville, Fla. E. P. Martinson, D. B. Wilson.

LEWIECKI, EDWARD M., Instructor in Mechanics, U. S. Military Academy, West Point, N. Y. A. Higdon, R. G. Valpey.

LEWIS, EDWARD H., Assistant Professor of Mechanical Engineering, University of Florida, Gainesville, Fla. J. E. Kiker, T. L. Bransford.

LEWIS, FRANK T., Manager, Manufacturing Personnel Development Services Dept., General Electric Co., Schenectady, N. Y. M. M. Boring, D. S. Roberts.

LI, M. C., Assistant Professor of Civil Engineering, University of Akron, Akron, Ohio. R. D. Landon, E. K. Hamlen.

LINCOLN, ROBERT T., Head, Electrical Department, L. I. Agricultural and Technical Institute, Farmingdale, N. Y. A. B. Bronwell, W. R. Woolrich.

LOODE, GARRETT, Instructor in Mechanical Engineering, General Motors Institute, Flint, Mich. H. M. Dent, V. M. Irwin.

MCCRACKEN, LESLIE G., JR., Instructor in Electrical Engineering, Pennsylvania State College, State College, Pa., (On leave); Electronic Scientist, Naval Research Laboratory, Washington, D. C. G. Abraham, J. Harms.

MILLER, WENDELL E., Assistant Dean of Engineering, University of Illinois, Urbana, Ill. S. H. Pierce, H. H. Jordan.

MILLETT, MERLIN L., JR., Assistant Professor of Aeronautical Engineering, Iowa State College, Ames, Iowa. G. Murphy, E. W. Anderson.

MORTLAND, JAMES A., Director, Planning, Building and Zoning, Sarasota, Fla. J. Weil, J. Reed.

MYERS, EARL A., Instructor in Agricultural Engineering, Pennsylvania State College, State College, Pa. E. B. Stavely, L. S. Rhodes.

POTTER, PAUL C., Director of Personnel-Engineering Staff, General Motors Corporation, Detroit, Mich. K. A. Meade, R. L. McWilliams.

REINHARDT, GEORGE C., Director, Military Art, The Engineer School, Fort Belvoir, Va. W. N. Underwood, E. J. Peterson.

RICHARDS, ALVIN M., JR., Assistant Professor of Civil Engineering, University of Akron, Akron, Ohio. W. M. Petry, E. R. Wilson.

RICHTER, JERRY G., Instructor in Mechanical Engineering, Pennsylvania State College, State College, Pa. C. Birnie, Jr., E. B. Reynolds.

ROBERTS, VERNE E., Assistant Professor of Mathematics, University of Alaska, College, Alaska. E. H. Beistline, E. F. Rice.

SHEARER, JAMES E., Assistant Professor of Mechanical Engineering, University of Akron, Akron, Ohio. E. R. Wilson, M. Bezbatchenko.

SHUGA, MICHAEL, Instructor in Civil Engineering, Fenn College, Cleveland, Ohio. J. Arendt, F. V. Higgins.

SHUPE, JOHN W., Assistant Professor of Applied Mechanics, Kansas State College, Manhattan, Kans. A. O. Flinner, R. E. Crank.

SIEVERS, GEORGE A., President, Industrial Engineering Institute, Milwaukee, Wis. B. G. Elliott, W. S. Coffingham.

SMITH, BOB L., Instructor in Civil Engineering, Kansas State College, Manhattan, Kans. M. A. Durland, R. C. Potter.

STAPH, HORACE E., Assistant Professor of Mechanical Engineering, University of Texas, Austin, Tex. B. F. Treat, W. R. Woolrich.

STUMPE, WARREN R., Instructor in Mechanics, U. S. Military Academy, West Point, N. Y. A. Higdon, R. G. Valpey.

THOMPSON, ARTHUR T., Associate Professor of Engineering Research, Pennsylvania State College, State College, Pa. A. Addison, R. A. Hussey.

THORSON, INGOLF E., Associate Professor of Architecture, Kansas State College, Manhattan, Kans. R. C. Potter, M. A. Durland.

VAN ZEELAND, WILLIAM A., Assistant Professor of Electrical Engineering, Milwaukee School of Engineering, Milwaukee, Wis. S. S. Neu, R. J. Ungrodt.

WAKAI, THEODORE Y., Assistant Professor of Chemical Engineering, Lafayette College, Easton, Pa. R. R. Jones, J. G. Reifsnyder.

WEHR, MENTZER RUSSELL, Professor and Head of Physics, Drexel Institute of Technology, Philadelphia, Pa. R. V. Giles, S. J. Leonard.

WENIGER, WILLIBALD, Head of Physics and Electrical Engineering, University of Alaska, College, Alaska. E. H. Beistline, E. F. Rice.

WINTER, WESLEY P., Instructor in Industrial Engineering, Pennsylvania State College, State College, Pa. R. S. Farwell, E. E. Bullinger.

YOUNG, WILLIAM R., Instructor in Engineering Drawing, Iowa State College, Ames, Iowa. J. S. Rising, J. K. Walkup.

464 new members elected this year

Reserve this date . . . .

June 22-26, 1953

ANNUAL MEETING

UNIVERSITY OF FLORIDA

GAINESVILLE, FLORIDA

Do You Know—

► The following are some residual items of Society activities not reported in the March or April issues of Journal.

► The Annual Meeting is just around the corner—June 22–26. By this time, you should have received the Preliminary Program and the reservation cards. Here are a few items of special interest regarding the Annual Meeting program . . . The Tuesday morning General Session Program will deal with the general theme of Engineering Education and Profession, with our own President Woolrich speaking on the subject of "Engineering Education and the Engineering Profession" and Karl McEachron, Sr., Consultant on Professional Employee Relations of the General Electric Company, speaking on "Unionism and the Engineering Profession." This subject has suddenly sprung into full-scale importance for the engineering profession as a result of expanded activities of unions . . . Perhaps you have noticed that the General Entertainment for Wednesday evening will be the current Broadway hit "Bell, Book and Candle," staged by the Florida Players. Also, President and Mrs. Miller are inviting the Membership to a reception at their home on Tuesday evening . . . For other features, please refer to the Preliminary Program. An attractive ladies program has been arranged by the Florida Local Committee.

► We have received several inquiries regarding the procedure for nomination of officers of the Society, so here is a quick resume . . . A nomination form was published in the February and March issues of the Journal. Nominations are to be sent to the ASEE Headquarters, where the information is compiled and forwarded to the Nominating Committee. The Nominating Committee consists of the members of the General Council who retire from the Council in June, together with the three immediate past presidents. The Senior Past President (this year Dean Thorndike Saville) serves as Chairman. The Nominating Committee members add their nominations, after which a tentative (non-committal) ballot is taken by mail. The final selection is made by the Nominating Committee assembled at the Annual Meeting. The nominations can also be presented on the floor of the General Session at the time of the election. If you wish to make nominations, please send them to the Headquarters Office either on the nomination form printed in the Journal or by letter.

► The Committee on Graduate Study has completed revision of the Manual of Graduate Study which is summarized in this issue of the Journal. This was a two-year project undertaken by a committee of 9 members, all of whom are actively directing Graduate Studies in engineering colleges. Our publication budget did not permit publishing the entire Manual in the Journal, but copies of the complete Manual can be obtained from the Secretary's Office at 50¢ each. Please include remittance with your order.

► The Paper Contest for Young Engineering Teachers has met with enthusiastic response from our younger members. Most Sections of the Society report at least three to five entries. Regional judging is now under way to select the semi-finals. Awards for the two prize-winning papers will be presented to the recipients at the Annual Banquet.

► At the suggestion of the Division of Relations With Industry, several Sections of the ASEE have expanded their activities and programs in order to bring into active participation a number of leading engineers and industrialists from local industry. The Sections which have undertaken this type of program have found it highly profitable, both from the stand-

point of obtaining stimulating material and also that of establishing friendly working relationships between industry and the colleges. George Lobingier, Chairman of the ASEE Relations With Industry Division, states that this Division will be glad to cooperate with any Section which wishes to develop similar activities or arrange for a sub-division of the RWI Division.

► A barrage of letters informs us with a slight tinge of chagrin, that we overlooked in our listing of publications of the Society in the March issue of the Journal, the highly commendable Bulletin of the Engineering Mechanics Division. This Bulletin is doing a superb job in bringing the latest advances in the teaching of engineering mechanics to the teaching profession. Congratulations on a good job!

► A few copies of the report of the Committee on the Improvement of Engineering Teaching are still available and can be purchased from Headquarters Office at a price of 15¢ per copy or $8.00 per hundred. Over ten thousand copies of this report have been sold, indicating its widespread popularity. Please enclose a check with your order.

► An excellent compilation of papers on the Fifth College-Industry Conference sponsored by the Relations With Industry Division is now available in mimeographed form from the Headquarters Office. This includes 11 papers dealing with recognition and encouragement of gifted students, recruiting potential talent for the engineering profession, what must the individual do toward continued learning, appreciation of the humanities by the individual, motivations in industry, and other interesting subjects. The price is 50¢ per copy. Please enclose a check with your order.

► Again may we call your attention to the fact that the Fall Meetings of the ECRC and ECAC, will be held in conjunction with the Annual Meeting of the ECPD at the Statler Hotel in New York on October 15–17. The program details for this meeting have not been fully developed, but the conferences will be open to all members of the Society.

► The Executive Board suggested that the Committees and Division of the ASEE take advantage of this Fall Meeting to hold Committee meetings for the purpose of formulating the program for the year ahead. A number of meeting rooms will be reserved at the Statler on October 13.

► The Committee on Evaluation of Engineering Education will hold a two-day meeting preceding the Annual Meeting of the Society in Florida. The work of this Committee for the past year has been financed by a grant of $3,000 from the Engineering Societies Foundation. Also, the ECPD Societies have offered to contribute funds to help finance the project. This financial assistance has been extremely helpful in making it possible for the Committee members to meet and carry on the work of the Committee.

► The new membership drive, which was aimed primarily at younger faculty members, has yielded over 700 new members. The Membership Committee deserves a hearty vote of thanks for their excellent cooperation.

► A number of Divisions of the Society are cooperating with the American Standards Assn. in preparing standards. The Drawing Division is particularly active currently in the preparation of international drafting standards.

► A study is currently under way in the English and Humanistic-Social Divisions of the Society to determine the course offerings in these fields in engineering colleges throughout the country. A report on this will be presented at the joint dinner of the two Divisions in Florida.

► Professor Sampson of the Univ. of Fla. called attention to the dinner meeting of the Young Engineering Teachers' Committee which features Rear Admiral Wm. S. Parsons, USN, on the subject "Problems of Weapon Design and Development." Incidentally, Adm. Parsons, flying over Hiroshima, attached the fuse to the first atomic bomb in history to be delivered against a military target.

"Let's Clean House"

By JOHN R. SNELL *

Head Dept. of Civil Engineering, Michigan State College

House cleaning time is at hand. It is long overdue. In fact, the point has been reached when each man must decide for himself whether he will be part of the house cleaning crew or part of the dirt. This is the conviction which has been burning deeper in me each week in the year since I closed my consulting engineering office in Metropolitan Boston and accepted my present position at Michigan State College.

This conviction was born out of my 19 years' experience with the engineering, architectural and construction fields and it is principally to the men in these professions that an appeal is made. To make the story real, I have selected a few true examples purposely withholding names places, etc., as my intention is not to burn down a few houses but to ignite a larger fire, and to inspire men to a general house cleaning program. I bear malice toward no group or no individual but am tremendously concerned with the infiltration of moral laxity in the construction profession. If some of my statements or examples seem to be unjust or undeserving or a bit shocking or shaking, remember that such action might well be appropriate. Were you asleep in a burning building you would welcome such a shaking!

The Problem

Not long ago, Mr. D——, a structural engineer, and I visited a nearby state commissioner of public works. We had eyed the state's hundred million dollar highway program with a view toward designing a few bridges and overpasses.

The commissioner gave us a warm welcome. "A great deal of work will shortly be given to consultants," he said. We gave him a prospectus containing our experience and qualifications. He was unquestionably impressed by this prospectus and concluded the interview with warm assurance that we would be "kept in mind."

We followed up this interview with several subsequent calls, in all of which the commissioner was most friendly. At length we approached a state representative, Mr. S——, to see what he could do in our behalf. Although Representative S—— represented the party which was not in power at the time, we were assured that this made little difference and that he would be happy to see what he could do.

A few days later the telephone rang. The voice on the other end of the line was wary. Mr. O——, this is Mr. A——. I'm chairman of the B—— State X—— Commission and just had a nice visit with Representative S——. I believe we have some good news for you. We shall be glad to award you the job of designing one or two of the proposed bridges. You understand, of course, that it is customary to make a small contribution to the political campaign fund of the party—to be exact, 10% of the fee is usual."

My associate and I promptly turned down this proposal. Mr. A—— was nonplussed at our refusal; he was obviously accustomed to having such offers accepted without question.

A few weeks later, we learned that the job of designing twenty of these bridges and overpasses had been awarded to a firm owned in part by a close relative of a politician in high office.

* In collaboration with Walter A. Snell.

This is graft, unquestionable and undiluted. Last year, by similar means with variations, an estimated two and a half billion dollars in public funds were stolen! Even in these days of massive federal budgets, two and one-half billion dollars is a lot of money—about $15 on the average tax rate, three times the amount spent yearly on education, enough to clothe comfortably every person in the United States, enough to buy each family in the United States a 21-inch deluxe television set every three years.

Those who aren't in a position to know facts illustrated in this true story might well ask a few questions! How can corrupt politicians steal two and one-half billion dollars right out from under the public's nose? Why is the public largely ignorant of this vast graft? How can America, as leader of the world, criticize the graft and corruption of other governments and yet tolerate that at home which staggers the imagination? Why does not "somebody do something about it"? What can we do about it?

No echelon of our government is free from guilt. Municipal, state, and even federal politicians are guilty. Their system of obtaining this graft has been carefully worked out; the arrangements are strictly private and consist principally of "kick-backs and contributions" from engineers, architects, contractors and materials manufacturers engaged in the construction of public works. The system is so deeply entrenched that only rarely is the public aware of its existence and only then when some politician, fallen from grace, is made the scapegoat by his own political party and, rarer yet, when one is indicted and convicted by some "reform" district attorney. In most cases the system operates smoothly, to the extent that men are willing to pay as much as $10,000 for a political job which pays no salary. Even 90% of the men in the construction industry themselves are ignorant of exactly what goes on and how they are being taken advantage of by a compromising few.

The principals in the construction industry are well aware of the strangle-hold these ruthless politicians have on them. Yet collectively they have done little about it. The majority of these men operate their businesses on the principle "one must eat" rather than on the moral standards of good business. If they should oppose the system individually, they would commit professional suicide. And yet collectively they have failed to put a stop to these corrupt practices because of mutual distrust, fear of competition and just plain lack of backbone. This fear of "sticking one's neck out" even extends to engineers engaged by our institutions of higher learning to mould our future designers and builders!

More Examples

Let's consider a few more examples. A few years ago, I collaborated with Mr. L——, an architect, in the design of a large municipal structure for an industrial city with a population of about fifty thousand. Mr. L—— had been retained under an honest administration; he had made considerable progress on his design when a new administration took over. A new "building committee" was appointed with the mayor as chairman ex officio. Mr. L—— was approached and informed that he must make a contribution of $15,000 to be divided between the mayor, the committee and the political campaign fund. Since the architect's fee was somewhat under this sum, he was instructed to make arrangements with the contractor to obtain this money from the job. The architect refused and agreed to finish the job only if no demands what ever were made upon him. When, after much deliberation, the mayor and the committee realized the difficulty of explaining to their constituents the necessity of changing an architect of such prominence in the midst of his work, they decided on a different strategy. They dealt directly with the contractor and secured far more funds than they had originally demanded.

This is the typical approach of the corrupt politician. Yet, only rarely, as in

the case of Mr. L——, does a member of the construction industry resist such an approach. Usually, as in the case of this contractor, they acquiesce most readily to these corrupt demands with the attitude that such acquiescence is customary and necessary to secure and hold a public works job.

Twelve years ago, America was feverishly re-arming, and army camps and airfields were being built everywhere. Engineers and architects worked overtime to keep up with the military demands for more training facilities. Upon the initiation of this program, all engineers and architects of consequence in an eastern metropolitan area were invited by a Washington representative to a meeting supposedly concerned with the technical details of the program. When the meeting convened, its true purpose became all too obvious. That purpose was to explain the 5% kick-back involved in these federal defense jobs and the channels that had been established to receive them. Of the several scores of firms attending this meeting, only two demonstrated courage enough to oppose this game and refuse to "play ball." In our present re-armament program there is every evidence that the same kick-back procedure has been followed.

Not only does inertia encourage such corrupt practices, but every sizeable city has its group of favored engineers and architects, generally of questionable ability, who are so favored because of their willingness to "cooperate." These men make little pretense of being good engineers or architects. They are interested only in making money and care little how it is made. They have successfully blackened the eye of the entire construction profession.

A prime example of such men is the well known firm of M——, T—— & B—— located in a large coastal city. Less than four years ago one of their key men admitted paying twenty thousand dollars in bribery to a political boss of an industrial town in payment for being granted a job designing a municipal sewage treatment plant. Then again, about three years ago, when a group of various engineers were invited to submit proposals to a small nearby town for certain improvements in its sewage system, most of the engineers offered an approximate estimate of $200,000 as the cost of such improvements and agreed to take the job in accordance with standard ethical practices. Yet the firm of M—— T—— & B—— informed the town that, through their special abilities, they could build this system for only $150,000. With this and an appealing sales talk plus a substantial bribe for one of the committee members, the firm successfully obtained the design work. When the job was completed, the costs ran well over $300,000. The committee was certain that there was collusion between the engineering firm and the contractor, but they could prove nothing.

Not only has this firm constantly obtained its jobs by bidding under the standard published fees, but it has constantly collaborated with certain equipment and materials manufacturers and specified their products exclusively for the price of making their design for them, plus a substantial cash kick-back. In one instance in which they specified a certain product, the bid came to $10,000. However, the client, knowing something of construction prices, suspected foul play and forced the use of a material of equal quality which came to only $900; this netted a saving of $9,100.

This group of engineers has made their services so profitable to the corrupt political bosses of many cities that they are almost constantly being forced down the throats of architects as collaborators on large jobs.

F.B.I. Hands Are Tied

When they hear of these facts, the first question people ask is, "Why doesn't somebody do something about it? Why doesn't the F.B.I. do something about it? Don't they know about it?"

The answer is yes: they know about it.

They are aware of innumerable specific instances; but since these instances are usually local, they remain outside federal jurisdiction.

Mr. F——, a contractor, told me not long ago that he had lunch recently with an F.B.I. agent in a well known restaurant. At the next table were two well dressed gentlemen. When they arose and departed from the room with brief cases in hand, the agent confided in Mr. F—— that these were two of the mayor's "bag" men, that they were at that moment on their way to the office of Mr. B——, one of the city's political architects who that morning had just received a substantial check, and that they were headed to receive the kick-back money. The agent hastily added that, although he personally had intimate knowledge of the situation in this city, the F.B.I. was not authorized to investigate such matters and bring the guilty to justice.

Contractors Handle the Big Money

The big money, however, comes from the contractors. While architects and engineers are consistently asked to kick-back a percentage of their relatively small professional fees, the crooked politician, by keeping these professional men involved in illicit practices, can keep them "in line" while he is dealing with the big money which must pass through the hands of the contractor.

Usually the relationship between political boss and contractor is a friendly one; and the problem of extracting funds from the public's pocket is relatively easy. The "usual percentage" expected by the crooked politician is common knowledge, and each contractor carries this additional amount in his bid. Should some recalcitrant contractor "break faith" with his corrupt client and fail to carry such an amount and, upon award, refuse to pay this predetermined percentage, he is severely punished. The political bosses may instruct the resident engineer on his job to make unwarranted demands on him and require him to rebuild portions of his work which were already correctly built. Regular payments may be delayed or withheld and false claims made concerning the "unsatisfactory" quality of his work. Many would-be honest contractors have been "crucified" by these crooked politicians.

Frequently, contractors are encouraged to choose among themselves the "low bidder" for each specific job. This practice of secret collusion makes it easier for the politician to sell the public on the idea of his integrity; from all appearances the low bidder always gets the job and no particular firm seems favored. Recently, a large midwestern contractor, Mr. D——, attempted to break in on this type of collusion in a southern metropolis. Mr. D—— submitted a bid on a large public housing project in this community; his bid was one million dollars below those of the local contractors who were in collusion. When the bids were opened, and the local contractors discovered their embarrassing predicament, they attempted to exclude Mr. D—— on the basis that his bid was much too low, that it would be impossible to construct this project for such a sum. Mr. D——, however, proved that he could not only do the job for his bid price but could still make a substantial profit. In this case, he was awarded the job. But how many millions of dollars had these same contractors and their political bosses stolen before? How long had this collusion been going on? Only they know.

Two years ago last summer another contractor, Mr. C——, told me that he was being paid $35,000 a year for disposing of the refuse from a nearby city with a population of 150,000 and that he annually received a similar amount from the revenue obtained from private dumping. In substance he said, "I don't know what I would do if the district attorney inspected my confidential books. They show kick-backs of about $25,000 per year, and they show to whom the payments were made. It would get a lot of people in trouble, including myself."

And thus these practices go on, unnoticed in most cases by the public. Although most States have passed laws requiring sealed bids by three or more contractors for all public works and although the approach of the crooked politician to the contractor is rendered somewhat more difficult, friendship and collusion between these two is still possible. And the result is a whopping theft of an estimated two and one-half billion dollars per year from the public pocket.

The People's Choice

The public has heard a great deal about corruption in high places. Crime investigation commissions have brought light in many dark and dirty corners. Mink coats, tax scandals, influence peddling, rackets in veterans' benefits, communist infiltration, post office scandals, "fixing" in the law enforcement, and RFC loans are only a few. Indignant, impatient voters came out from behind the clouds of confusion and indifference to cast their ballot for a "house cleaning." The job is too big for one man or one party. The vote was not so much for a new party but for a new moral fiber in Government!

We in the construction industry must heed this vote. If our leaders are not heedful, we must raise up new leadership. At this time the officers of our professional societies might well be selected on the basis of their ability to give courageous leadership rather than for political expediency or past technical accomplishments. Those officers of our societies who have wormed their way into the inner circle and up the ladder of secretary, treasurer, vice president and president and lack the intestinal fortitude to take a firm stand on a moral issue do not command their profession's respect. A good captain does not let his men stand around painting the cabins while the ship is sinking!

Graft Causes Even Greater Wastes

The public must know that this 2½ billion dollar graft is only a part of the waste and inefficiencies caused by this system. Many of the programs sold to the public are undesirable, poorly planned, and some, even unusable. For example, an official report of the American Society of Civil Engineers shows that 25% of all municipal incinerators are abandoned within the first few years. These stand as mute monuments to pillaged engineering fees, fake engineering, crooked deals with incinerator firms and kick-backs to corrupt politicians. The record shows far too many cases where the structures built under this corrupt system are lacking in sufficient cement or other basic ingredients and must be repaired or entirely rebuilt after a very few years instead of lasting a lifetime.

And more important than the dollars so cleverly lifted from their pockets, the public must realize that corruption breeds corruption and that such practices can only muddle the reasoning ability of their political leaders and stamp their decisions with the dollar sign. We must realize that such corruption is not concerned with public benefit but only with personal enrichment, not with the preservation of the democratic ideal but only with the advancement of personal power. We must realize that our leadership may become so polluted that it may be impossible for it to hold the minds of men at home, as well as abroad, against the militant materialism of communism. We must realize that, muddled as we are, we can never be secure from encirclement and ideological collapse, not even from actual military defeat and conquest. We must know the facts, and we must do some serious thinking. Let us not be deluded into the thinking that the election has solved all our problems.

One need only take a look at China to be terribly frightened. The Nationalist regime was riddled with graft and despite the hundreds of millions of dollars that Uncle Sam poured into that country, only a few thousand determined men with a plan inspired in Moscow gained control of all of China's 450 millions. And now

they have invaded Indo-China and Korea and are threatening to precipitate the world into an atomic war. Graft was the principal cause of the fall of the Nationalist government, even though that government had taken many steps toward true democracy. Paradoxically, at one time the United States refused to grant further aid to the Nationalists until they had cleaned their house of graft, yet at that same time, there was more corruption in the United States than there ever was in the Chinese Nationalist regime. Let's all help our new broom sweep clean!

The experiences of the past five years have been a bitter and costly lesson to the 450 million people of China. The American people must profit by this lesson; we cannot afford to learn the hard way. Unless we learn, the world may be approaching the New Dark Ages. And the fault will be ours, not because we failed to comprehend and put into practice our vast technological knowledge but because we failed to live up to the basic moral and spiritual truths of our American heritage. Our founding fathers understood these principles and founded this great democracy firmly upon them. But today we are defying these truths and, in so doing, are adulterating true democracy and are bleeding our American way of life to death.

Although this shakedown of the 30 billion dollar construction business is only one of many areas requiring attention we must take action here, as well as elsewhere, if we are to meet this threat to our existence. What can be done?

The Construction Profession's Battle

Although the immediate power to stop this annual leakage of 2½ billion dollars into the pockets of politicians rests in the hands of the construction profession, as yet almost nothing has been done or even seemingly contemplated. First of all, our profession seems oblivious of the gravity of their actions. Secondly, we seem afraid of one another, of competition and of not being successful in our own businesses. Thirdly, we have compromised and do not know how to stop. Fourthly, we lack an effective organization and red-blooded leadership.

These are reasons why the construction profession has not cleaned house, but they are not excuses. Even a small minority of architects and engineers could put an effective plan into action, convince the majority to support actively the plan and either force the remaining few to fall in line or force them out of business. The basic principles behind such a plan might be:

1. Architects and various engineering societies agree on a modern, aggressive, high level code of ethics, which would closely define the extent they may go to secure a job—no "commissions," "finder's fees," or "kick-backs" of any kind would be tolerated.

2. Competent accountants would be employed to set up a single standard system of bookkeeping which all cooperating firms would follow.

3. Selected honest accounting firms would then be employed to audit the books of all architects and engineers in each area and report all infringements of regulations to an elected board of professional men.

4. All cases reported would be judged by this board and appropriate disciplinary action imposed. Punishment might include a heavy fine plus revoking of the professional licenses of the principals of the firm.

5. A system of double check can be called by any firm suspecting the corrections of the official audit. They can call for outside auditors to recheck the books of any firm at any time but must bear the cost of such an audit if the books are found to be correct.

6. Firms unwilling to cooperate with such a plan will first be given very unfavorable publicity and, if shown to be collaborating with political grafters, will be brought to trial by the board in the criminal courts.

7. Present grievance committees which are presently almost nonfunctional should

be given *aggressive* policy and rules with teeth.

To be effective, the contractors should follow a similar plan especially tailored to their business methods. It is further suggested that the architects' and engineers' control board include two contractors as ex officio members and that the contractors' control board include one architect and one engineer as ex officio members. This interchange would permit mutual assistance and a double check on one another if the plan is to work. Only courageous men of unquestionable moral integrity should be selected on these boards.

The Statesman's Battle

If the battle for honesty is won in the construction industry, then the source of revenue for the grafters will automatically dry up. But if this battle is lost, then drastic measures may be required by men in public life to insure reform. Such measures may involve:

1. Cooperation with the reform elements in the construction industry.
2. Exposure of the crooked deals of their fellow public officials.
3. Voluntary, perhaps compulsory, opening of every public official's personal financial books for review by a citizens' control board with the aid of an applicable system of accounting and auditing.
4. Instilling of moral and spiritual awakening in the personal lives of the men in public office.

An important battle may have been won against entrenched corruption in all levels of government last November 4th but the war against corruption never ends but merely changes from a declared war to an underground guerrilla war.

The People's Battle

We, the people, are the victims of this vicious graft. As victims we should be the most interested in the search for reform. Some steps that we may take are:

1. Arouse friends, clubs, groups or churches to the tremendous urgency of this battle for public honesty as a prerequisite for the survival of our democratic way of life.
2. Dig up facts on recent corruption and have them publicized to arouse public indignation and action.
3. Nominate, campaign for, and "vote-in" honest and competent leadership.
4. Associate with men in public life; if their views and actions are dishonest, inspire and persuade them to reform or, if unsuccessful, expose and remove them from office.
5. Become acquainted with men in the construction field, inspire them into action in accordance with the program outlined previously.
6. Lastly, we are not in this fight unless we are willing to start with ourselves. We may not have paid kick-backs to corrupt men in government but what about expense accounts, "borrowed books" or a hundred lesser things. Our conscience can be very specific. And let us not forget that honesty is an absolute moral standard.

A final word. Men who steal from the public till are likely to be brilliant, influential and crafty. When cornered, however, although some may be desperate and fight, most merely turn yellow. Nonetheless we must plan the attack well for the opposition will be strong and will strike in very subtle ways.

As our men in Korea continue unflinchingly to battle the enemies of Democracy abroad, let each of us do our utmost to defeat the more deadly enemies at home. America's greatest need is a moral and spiritual awakening starting in ourselves. Then and only then can we lead the world to sanity and peace.

Engineering History—A Pedagogist's Problem*

By CARL L. SONNENSCHEIN

Visiting Lecturer, Department of Engineering, University of California, Los Angeles

Are there reasons why the history of engineering, and of engineers, should be investigated and written? We believe there are and the purpose of this paper is to present those reasons and also to point out some of the problems which would be associated with such a project.

As engineers, rather than as philosophers, we are prone to demand the demonstration of a need before we extend ourselves to attain a solution. The question before us will therefore be dealt with in the manner of the engineer.

Engineering is an effective force in the community only insofar as the men who serve the profession are competent. Obviously, then, if the present day students of engineering are deficient for lack of historical prerogatives or traditions it behooves the teachers of engineering to correct the situation. Often it has been said that a man who feels pride in his own work, and in the work of his colleagues, is one who accomplishes greater things. In simpler words, a man who is proud of his profession is generally one who will make a greater contribution to that profession because of a feeling of necessity to prove worthy of it. Pride may either be false or it may be based upon sound facts. We are prone to believe that today's engineering graduate is not equipped with a sound basis for pride in our profession.

Consider the legal profession. There are few men, to our knowledge, in that profession, who are not able to speak with pride of the great jurists of the past. It has been found expedient, in this profession, to include a good deal of history in the required curricula. Therefore, the neophyte lawyer is well acquainted with the men, and their accomplishments, who have made the great advances in his profession.

In the medical profession one finds a well recognized discipline of medical history. It is true, however, that the extent to which this discipline has become established is subject to wide variation. Some medical schools possess departments of medical history which have equal stature with those departments which are either clinical or theoretical in concept. In other instances, specific courses concerning the history of medicine are required of all students. Additionally, there exist journals which are conducted solely for the purpose of encouraging and espousing the subject of medical history. Accordingly, a relatively large percentage of medical graduates are historically conversant so far as their own profession is concerned.

Consider, however, our undergraduate engineers. What does the average student know of general history, much less the history of engineering? The answer must be that he knows extremely little. Let us inquire as to the reasons responsible for this state of affairs.

To what extent has the history of engineering been evaluated and written? To what extent have the engineers relinquished their claim rights to the physicists, chemists, and mathematicians? What have we as engineers done to alleviate the situation so as to clarify the status of many of history's outstanding intellects?

No Coherent History of Engineering

To our knowledge, no coherent history of engineers, or engineering, beginning

* Presented at Annual Meeting of ASEE, Dartmouth College, June, 1952.

with antiquity and including the 19th century exists, although some segmental histories have been written dealing with particular periods, or men. Consideration of available material would seem to indicate that the history of engineering is not a continuous one but has lapsed as civilization progressed. The latter conclusion is obviously fallacious.

Fortunately, it is not necessary to dig into the lists of the unknowns before one finds the names of men who might be considered to have been engineers or who participated in great engineering works. Actually, most of the men whom we would intuitively want to call engineers have been already claimed by other groups as members of their particular histories. Perhaps a few examples, based upon intuition rather than the "Historical Method," might serve a purpose at this point.

Archimedes, thought of by some as the greatest intellect of antiquity, is most commonly known as a philosopher and mathematicion rather than as an engineer. Yet, consider his invention of the irrigation device which we now know as "Archimedes Screw." Surely here is an example of a man providing a solution for a highly practical problem. For the military man and engineer the invention of catapults and the statement of the law of levers was a notable contribution in an engineering sense. Why then should not the engineers claim Archimedes for their own rather than leaving him solely to the mathematicians and philosophers?

Leonardo da Vinci and Michelangelo, the two great contemporaries of the latter 15th and early 16th centuries, are known to all. True, the engineering and inventive genius of da Vinci has been given wide publicity of late, but what of Michelangelo? The artists and architects would claim Michelangelo for their own perhaps without considering some of the facts in the case. Whereas the architect, in the strict sense of the word, is the one who must design a building, the engineer is the one who will ultimately determine the method of construction and supervise it. In these activities, Michelangelo was outstanding. Military fortifications were of greatest importance in that period and Michelangelo was called upon to design and to construct many such works.

Pure Mathematicians

Next consider a few men who are generally known to posterity as pure mathematicians. The question which must be answered regarding these men is whether or not the mathematical work which they produced was the off-shoot of purely philosophical contemplation or whether it stemmed from mature consideration of some practical problem. Pascal, Newton, the Bernoullis, Laplace, Monge, Fourier, Cauchy, and Poncelet, to name a few, are all men whose works may be judged by the criterion of the foregoing question. A detailed study of the biographies of these men perhaps would indicate that their greatest mathematical contributions were a result of their studies of practical engineering problems and situations: Pascal in fluid flow; Newton in mechanics; the Bernoullis in solid and fluid mechanics as well as strength of materials; Euler in analytical mechanics and hydrodynamics; and so the list goes. The studies which these men made were not to lie dormant for many years but were applied, upon the presentation of the solutions, to practical problems of bridge construction, hydraulic systems, ordnance design, road construction, and all the varied fields of engineering then known.

Among those men previously mentioned both Monge and Poncelet were military engineers interested primarily in the construction of military fortifications and weapons. Monge generally is credited with the invention of Descriptive Geometry, a method of graphical solution of certain problems whose importance to the engineer is obvious to all of you. Poncelet held the positions of Professor of Mechanics at Metz and later the Professorship of Applied Mechanics at Paris. Surely the latter named positions are ones which would very easily be recognized in our engineering colleges.

Boyle, Hooke, and Lavoisier are gen-

erally considered to be outside the field of the engineer. However, in addition to their many other achievements, these men contributed substantially, and practically, to the engineering profession. Boyle might never have been able to propound the law of gases, which is named after him, had he not first been able to design and build an improved air pump, this accomplishment to be followed by the invention of a high pressure air pump. Hooke's law is known widely, but the whole field of elasticity was this man's workshop and his contributions therein have not been of a minor nature. Lavoisier, known first and foremost as a chemist, was for a period a manufacturing or process chemist, as director of the State gunpowder works. Certainly the function which Lavoisier fulfilled would be classified as chemical engineering in our present society.

There seems to be little doubt but that the man who is hailed as the greatest of the Renaissance engineers is Galileo Galilei. Volumes have been written about Galileo and possibly they represent the majority of all that has been written, or is generally known, of the history of engineering prior to the 18th century.

At the other extreme one finds Joseph Marie Jacquard who contributed to the production technology of woven materials. This man who lived during the period of the French Revolution and the Napoleonic Wars invented a weaving machine to produce figured cloth; he also invented a machine to weave fishing nets. In retrospect, the accomplishments of Jacquard may not seem as important as some that have been mentioned, but under what circumstances is the engineering profession justified in ignoring these or any accomplishments when considered in the light of the period of their fruition? It is probably the men of Jacquard's stature who represent the continued growth of engineering even more than do those who made the great all encompassing, but infrequent, contributions.

As has previously been stated, the foregoing list is based upon an intuitive choice of men and events to illustrate a point and does not constitute coherent history. However, in order to separate historical "facts" from intuition it is necessary that the criticism and questions of the professional historian be anticipated.

Questions

The questions which would in all probability be asked by the historian are the following: 1) how does one define an engineer?; 2) how does one define an engineering work?; 3) what evidence is available to substantiate the claims made?; and 4) what further evidence may possibly be available which might appreciably alter the conclusions which have been reached? These questions lead us into a consideration of what the historian calls the "Historical Method."

As engineers we are readily able to concede that in order that a problem be discussed it must first be defined so that all can conceive of its limitations. The historian feels no differently and it is for this reason that the first two questions would be asked. Who is to answer these questions? Can the engineering profession adequately do so? If not, can an interim answer be used in order that the solution proceed? With all due respect for the many brilliant men who have attempted to formulate definitions of the "Engineer" and "Engineering," it appears that we will, however, have to accept some sort of an interim definition because of the lack of universality of acceptance of any. These definitions will necessarily be stated for all to see; they will be used as the criteria of choice of subject matter.

The latter two questions regarding evidence concern themselves with the methods of the historian in acquiring materials and establishing historical "fact" from these materials. It is not within the scope of this paper to go fully into a discussion of the "Historical Method" but merely to present its salient features. Gottschalk[1] says, "Historical Method consists of (1) the collection of probable sources of in-

[1] See Bibliography.

formation; (2) the examination of those sources for genuineness (either in whole or in part); and (3) the analysis of the sources or parts of sources proved genuine for their credible particulars." This is not a task to be taken lightly or one to be approached in any but an attitude of desiring to accumulate all possible relevant material so as to be able to draw from the sources all valid conclusions and to write a coherent history. It is absolutely essential that the historian of engineering does not fail to use properly the available material The historians of science have, at times, been accused of committing this error of misuse and improper interpretation. Undoubtedly, for proper evaluation, knowledge of engineering subject matter will be essential, but it must be accompanied by a working knowledge of the techniques of the historian for ferreting out and evaluating bits of information and evidence.

The term "coherent history" will now be defined. As used here a coherent history is not one which is merely biographical, in content, but is one which takes into account the social, economic, and political conditions and their interrelations with the development of men and ideas. Any particular history must be set into its proper framework as a single part of a complete picture. This represents a large task and a difficult one requiring not only the ability to obtain "facts" from material but also the ability to weigh all the factors involved. Of course, the job may be somewhat simplified if one were to deal with a subject such as the history of Engineering Education and to consider it from its internal aspects only. Then, conceivably, the external factors could be ignored. Needless to say, there are many such facets to the overall problem which might be attacked without broaching the larger issue.

We believe a recognizable need exists for a coherent history which can serve as a working basis for a more complete understanding and pride of, and for, the engineer and his profession. The attainment of this goal will very likely be accomplished by a relatively small group within, but the support of, the whole profession, and that group must take the full responsibility of doing an accurate and worthwhile job.

Conclusion

In closing, a final consideration: in what way will the required material be accumulated and digested, and how may it be disseminated to the students of engineering? In the first place it appears necessary that interested persons must band themselves together, in the manner of legal and medical men, into groups or societies for the promotion of engineering history. Secondly, it would behoove the individual teacher to obtain historical background material, for his courses, and to make this material an integral part of his subject matter along with the more technical parts. Possibly, individual courses on the history of engineering should be established and required in the various curricula, when adequate material becomes available. In self justification, we might add that the foregoing procedures are the ones used variously by the chemists, physicists, and mathematicians as they attempt to inculcate their students with a sense of professional pride based upon adequately documented histories.

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College Notes

The annual **Cornell Summer Laboratory Course** in Techniques and Applications of the Electron Microscope will be given this summer from June 15 to June 27, 1953, by the Laboratory of Electron Microscopy in the Department of Engineering Physics. The course under the direction of Dr. Benjamin M. Siegel will have Dr. James Hillier of the RCA Laboratories, Princeton, New Jersey, and Dr. C. E. Hall of M.I.T., Cambridge, Massachusetts, as guest lecturers this year.

The course is designed for those research workers, institutional and industrial, who have recently entered the field of electron microscopy or who are now planning to undertake research problems involving applications of this instrument. Further inquiries should be addressed to Dr. Benjamin M. Siegel, Department of Engineering Physics, Rockefeller Hall, Cornell University, Ithaca, New York.

* * *

The **California Institute of Technology** has created an Engineering Science option for candidates for the Doctor of Philosophy degree. This program of study is designed to give greater and more flexible opportunities to the student whose interests extend beyond the bounds of the current engineering fields. The boundaries between the fundamental concepts of these traditional fields are already diffuse and for many students should be ignored entirely.

The option was initiated at the beginning of the 1952–53 academic year and five candidates are now studying under the program. The first degree is expected to be conferred in 1954. This option emphasizes the engineering and scientific fundamentals rather than the applied aspects, and will be particularly helpful to students interested in careers in teaching and research. The engineering science candidate will include in his studies subjects lying outside the customary engineering program, such as classical physics and physics of solids, and new fields such as jet propulsion.

The Bases of Engineering Problem-Solving Skills*

By J. F. CALVERT, *Chairman, Dept. of Electrical Engineering;* H. P. SHELLEY, *Instructor in Psychology;* AND R. S. HARTENBERG, *Associate Professor of Engineering Mechanics, Northwestern University*

Advancing technology is characterized in part by solving engineering problems arising from new and unfamiliar situations. A few great advances have been made by those who are called geniuses; but the bulk of the advance has been made by piling minor inventions and discoveries on top of each other, the many small contributions making for a sometimes overwhelming whole, and recognized as a distinct step forward. It is in this mass area, the area in which a small contribution is made by each of the many, that we need to stimulate originativeness.

Inventions and discoveries, whether great or small, result from a carefully planned strategy and/or the ability of someone with the right equipment to capitalize and exploit a chance happening or thought. A formal educational process lays the ground-work for planned attacks and traces the patterns of the strategy of the *fait accompli.* If originality in thought, design, motivation and execution could be stimulated at the undergraduate level, then the right equipment, the right man and the right time might be brought together to bear in full on a tough problem.

Industry has long been gladly paying for "Suggestion Box" items at the shop level. Given the right situation, and a bright-eyed awareness of a shortcoming, many a man has come up with an idea, sometimes because of laziness, that meant real progress. The story of James Watt may be apocryphal, but it is said that he became tired of running around turning valves by hand and devised a system of levers and strings to do the job for him. He did much more for the old Newcomen engine—he introduced the external condenser and that was really thinking. There is, however, no good reason why the general ideas, plans and methods used by the people who have demonstrated ability along lines called original should not be studied for what can be culled from them, that they may be incorporated in an integrated way into the educational program of an engineering school. This program would stimulate the development of originativeness, creativity, ingenuity, inventiveness or whatever you want to call it. We'll call it creativity. Such a program might go a long way toward fulfilling the quest for more able men in that large area of problem-solving where engineers must deal successfully with new and unfamiliar situations.

The objectives of this and the companion paper, "Problem-Solving Skills in Engineering Drawing and Descriptive Geometry," are to make a preliminary report on an exploration into what may be done to develop latent creative ability. In making such an exploration, we have made two assumptions: first, that all degrees and levels of creative ability exist among engineering students, and second, that much can be done in terms of educational procedures to further the expres-

* Given at the Annual A.S.E.E. meeting at Dartmouth, June 1952.

sion of this ability by the student and graduate engineer. In the present paper we undertake to define the abilities and work-methods which we believe are characteristic of engineers who have been successful in original work. The companion paper reports on work in progress in the graphic and hence more tangible educational areas. The joint goal is to find educational procedures which will develop these abilities and teach these methods.

Report on Work in Progress

A large amount of work is in progress in relation to engineering education and also in relation to the broad field of creativity. In arriving at suitable descriptions of the characteristics of engineers who do creative work, we have compared our ideas with the literature of both psychology and engineering and also with the opinions of those who are successfully doing original work in engineering. We are interested primarily in engineering synthesis (design and/or invention) as contrasted with analysis or even chance discovery.

At this point we wish to call particular attention to the report presented at this Dartmouth meeting by the A.S.E.E. Committee on the Improvement of Engineering Teaching. In part, it discusses our problem in a broader setting, but of necessity in less detail and without reference to related researches.

Abilities and Work-Methods

The data to be reported in this paper are primarily a list of abilities and work-methods employed by those who are successful in solving engineering problems. The abilities or talents are specific personal characteristics of an individual; the work-methods are a logical sequence of steps or operations leading to a solution. Obviously certain steps of the work-methods imply the use of certain abilities, and they will be noted as they appear. The abilities and work-methods detailed in the following are opinions: it is believed that they are valid, and as such they will define the qualities we wish to develop through formal educational experience.

I. Specific Abilities
- A. Sensitivity to Needs and Potential Solutions.
  1. Idea Fluency— the ability to recognize problems needing solution and to produce potential solutions (a quantitative concept).
  2. Originality—the ability to produce uncommon, clever, or remote ideas which depart from the traditional (a qualitative concept).

The development of sensitivity to needs and potential solutions requires practice in constantly observing one's surroundings with an eye toward utility. One needs to raise questions such as: Why is something done as it is? How could it be done differently and better? Where else could the observed principle or technique be applied?

- B. Visualization
  1. Physical—the ability to visualize in two and three dimensions, designs, systems, and physical objects.
  2. Symbolic—the ability to visualize system parts or performance in terms of mathematical or other symbolic notation.
- C. Flexibility—the ability to change from one method of approach to a problem to another, or from one method of solution to another, i.e., the ability to change "set" or strategy.
- D*. Judgment—the ability to evaluate generalizations or consequences in physical or in symbolic representation.
- E*. Reasoning—the ability to reach acceptable conclusions on the basis of technical and scientific processes and also on the basis of realistic thinking, where economy, social consciousness, and need are considered.

* It might prove desirable to employ a combined statement for these two abilities.

F. Verbal factor—the ability to communicate ideas in a logical fashion and also, when necessary, in a persuasive manner.

G. Personal relations—a number of abilities are involved, e.g., getting along with others, having an open mind, consideration for others.

II. Work-Methods

A. Defining the Problem, or Making a Clear Statement of the Goals to be Achieved.

(The material within the quotation marks is taken more-or-less verbatim from the Report of the A.S.E.E. Committee on the Improvement of Teaching.)

"In endeavoring to make a concise statement of what appears to be a single problem, one might start by listing all factors thought to have a bearing. Through classification and consolidation, a strenuous effort should be made to express these factors in a form somewhat like the following:

1. The purpose is to produce (if a design is called for)..... or, the purpose is to determine (if an analysis is to be made).....
2. To overcome the specific inadequacy of .....
3. In such a way that ....."

B. Developing Solutions and also Selecting a Solution to be Worked on.

As indicated, these work-methods may be classified in two categories. For purposes of exposition these work-methods will be listed under the two separate headings, although in practice they are interdependent.

1. Developing Solutions
   a. Reducing the defined main goal into a series of sub-goals such that if all sub-goals are achieved, the main goal is achieved.
   b. Questioning the essential character of the sub-goals and their arrangements with a view to discarding one set of sub-goals in favor of a more advantageous set.
   c. Developing one's own symbol system to reduce a problem to its most simple elements if no commonly accepted system is available.
   d. Setting up other problems less difficult than the real one but which, by the successive introduction of more factors, yield increasingly better approximations until the last becomes an acceptable representation of the actual problem under study.
   e. Interpreting potential responses from a study of limiting or boundary conditions.
   f. Developing valid analogies which reframe a new situation in a more familiar form, and thus permit the application of theory and experience in one field to provide tentative or even final explanations in another area.
   g. Skill in "brain-picking"—a technique commonly employed by engineers administering research and development which is exceedingly efficient in obtaining pertinent information.
   h. Skill in library research.
   i. Skill in the use of time and energy so as to bring the best to bear on the toughest problems.
2. Selecting a Solution to be Worked on.
   a. Checking for matches and mismatches between the probable results and the desired results to discover vital, questionable or inconsequential differences.
   b. Skill in determining the probable satisfaction to be given the ultimate user by a given solution.
   c. Being on the lookout for by-products and their potentials.
   d. Preparing honest statements about the probable results of a proposed solution.

The specific abilities of idea fluency, originality, visualization, flexibility, judgment, reasoning, and verbal clar-

ity appear to be related to developing and selecting solutions.

C. The Negotiation of the Acceptance of the Solution.

It is usually necessary for someone to negotiate the acceptance of a problem before funds and time can be secured to work on it. Quite commonly it is necessary to keep up the interest of both those financing a problem and those carrying out the work. Finally, it is necessary to "sell" the completed work. The reactions of the client, and/or the potential consumer must be considered, and the negotiation must be so packaged that it gets across before the other fellow get tired of listening.

The specific abilities of the verbal factor and personal relations are of particular importance in this phase of problem-solving.

Survey of Research on Problem-Solving

As has been indicated earlier, the foregoing lists of abilities and work-methods were developed as a result of a series of staff conferences involving engineers and psychologists. The effort also reflects a fairly comprehensive review of the literature in the field of problem-solving as well as discussions with men in this area of endeavor. There is a close correlation between the checklist of skills proposed in this paper and with the literature in the broader field of problem-solving.

All of the specific abilities listed with the exception of Item I–G, which has to do with the problem of interpersonal relations in a team research project, can be found in one form or another in the work of Guilford on creativity (4). They were part of his original hypotheses and test battery and appear to be coming out as factors in his analysis. In addition, the work of Flanagan (3) on critical requirements for research personnel, although explicitly directed at critical requirements in terms of behavior, contains reference to many of these abilities. The behaviors listed in his checklist under "Identifying and Exploring Problems" would be included under our category, "Sensitivity to Needs and Potential Solutions."

Flexibility or the ability to change set is one of the most consistently appearing factors in studies on problem-solving. It is found in Maier's (8) early work; Luchins (6) has examined this factor quite extensively. MacLatchy's (7) study stresses invariablity of problem-solving methods in children. Shaw (9) uses it to explain the greater effectiveness of group problem-solving over individual problem-solving. The need for an ability to change set can be inferred from the critical behaviors Flanagan lists under "Anticipating Difficulties" ("Outlined alternative approach to be used if first choice failed") and under "Modifying Planned Procedures," e.g., "continued to follow old method or approach without change when evidence showed that it had failed" (ineffective behavior) and its effective counterpart, "adapting alternate procedures as soon as unforseen negative conditions or difficulties were encountered."

In addition to the more-or-less specific abilities of the problem-solver as a person, it is recognized that work-methods or ways of attacking problems are also important in problem-solving effectiveness. Although dependent upon the abilities of an individual, as listed above, they are independently related to problem-solving effectiveness, i.e., two people of equal abilities might differ in their effectiveness in solving problems because their work-methods differed in effectiveness. "Defining the Problem," as we have chosen to call it, would include the behaviors Flanagan lists under "Defining the Problem" as well as those listed under "Planning and Designing the Investigation." Bloom's and Broder's (1) "Check List on Problem- Solving," around which a program of remedial training in problem-solving was based, directs attention to understanding the problem, the setting up of criteria which a solution must meet, and the implications of the problem.

The reduction of a problem into a series of sub-goals was recognized by Bloom and Broder when they attempted to get their subjects to "break complex problems into more workable parts" and "to deal with each part separately." Under the category "Developing Systematic and Inclusive Plans" Flanagan lists "outlined a plan calling for each element of problem to be studied in sequence."

Item e under "Developing Solutions" calls for the development of one's own symbol system to reduce a problem to its most simple elements. This work-method has not been discussed in the literature. However, if it is true that reducing a problem to its simplest elements is a part of efficient problem-solving, then skill in the development of a symbol system which will permit this to be done more efficiently is a work-method that should be developed.

Item d under "Developing Solutions" calls for the gradual achievement of a problem-solution by the successive introduction of more factors to less complex problems. In Flanagan's checklist we find "Presented plans which include methods of integrating one factor or phase with others"—a form of behavior very similar to what we intend. It would seem that what we have in mind is what Duncker has termed productive problem reformulation. As he puts it. "The final form of a solution is typically attained by way of mediating phases of the process, of which each one, in retrospect, possesses the character of a solution, and, in prospect, that of a problem." The mediating phases in many cases amounts to the successive introduction of new factors into an originally simpler problem.

We have found no counterpart in psychological literature for Item e, "Interpreting potential responses from a study of limiting or boundary conditions." It is a specific technique that has applicability to many engineering problems.

Items g and h, "Brain-Picking and "Library Research," have to do with the kind of behavior Flanagan places in the category of "Collecting background information." We have distinguished between reviewing the literature and getting information directly from other people because it is thought that while the function is the same, different kinds of behavior are involved. Further, since there is a substantial time lag in the publication of research and since in the area of new problems much valuable thinking and research is never published because the solution has not yet been attained in a satisfactory form, it is important to be able to get this information.

Item II–B2a, "Skill in checking for matches and mismatches between the probable results and the desired results," refers to the selection of the solution to be recommended. It is quite likely that it will be impossible to empirically distinquish between this behavior and the judgment and reasoning abilities listed earlier. Perhaps it is at this level that the distinction between abilities and work-methods breaks down. It it likely that this is a result of the fact that the inference of abilities is based on behavior and when the behavior becomes complex, work-methods and abilities become the same. The behaviors listed by Flanagan under the category, "Interpreting research results" certainly involves the same sort of behavior with which we are concerned at this point.

Items II–B2b and d are included because the engineer's problem-solving activity does not stop with the determination of a solution. He must evaluate the solution in terms of its satisfaction to the ultimate user and he must frequently be able to present his solution in a careful scientific manner. Item II–C, "Negotiation of the Acceptance of a Solution," is included because it must be done if the engineer is to carry his problem-solving activity to a successful engineering conclusion.

Experimental research in the area of problem-solving has been primarily concerned with the determination of the factors or processes involved in problem-solving or in the development of selection and achievement tests. A few of the early

studies deal with training procedures, e.g., Maier (8), MacLatchy (7), Lapp (5). The training methods were very specific in nature involving a minimum amount of transfer. Although the results are promising, the methods are not directly suitable for use in an academic setting. Recently, Bloom and Broder (1) have published a study on remedial work in problem-solving, a study that is more directly pertinent to the task at hand. Their primary interest was in teaching students how to solve problems in a testing situation, and their remedial program was primarily individual although some work was done in groups. Again it appears that their work cannot be directly applied to the classroom in an established curriculum.

Summary

What we have tried to do is to outline the generalities invoked and used by those who are successful in solving the ever-present new engineering problems. The next step would be to have our students use these elements on problems that must be met with well-marshalled attacks involving speculation and decision, theory and method. This is not a plea for new curricula, but only a suggestion that present courses might become more meaningful by the application of new educational methods and problems which teach the basic laws of engineering and fundamental techniques and at the same time lead the student to greater ability for creative work. It is the authors' opinion that something must be done at every level within the curriculum.

The authors believe that the drawing courses furnish an excellent opportunity to demonstrate, extend and coordinate the usefulness of graphical methods as key tools needed for original work in many intricate engineering fields—kinematics, machine and system design, block diagram representation of dynamic performance, and to introduce the study of both graphical and machine computing techniques. A real and rewarding satisfaction would be gained by the establishment of a powerful current flowing beyond the first year, where drawing skill would be exploited as a tool of continued usefulness.

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Problem-Solving Skill in Engineering Drawing and Descriptive Geometry*

By R. A. KLIPHARDT

Associate Professor of Engineering Drawing, Northwestern University

Engineering is traditionally a problem-solving profession. However, the many ingenious solutions of the past constitute such a wealth of know-how they put a pressure of time on engineering education; we can easily become overly concerned with student's performance in his first job out of school at the expense of his total professional development. Normally, in engineering drawing and descriptive geometry, we emphasize industrial practices of recording size, shape, materials, surfaces, etc. But engineers use drawings and drawing skill in many ways; in fact graphic techniques and engineering problem-solving are inseparable. The question is, "How do we find time for the extras?"

Most graphic solutions of engineering can be introduced as problems in instrument work, whereas the patterns and designs used are less stimulating and take the same time. In the first weeks of engineering drawing, drawing board constructions of parallel lines, perpendicular lines, scale work, and geometric division of a segment are covered. The student can be given a simple truss and shown that by drawing a diagram of lines parallel to the loads and members of the truss with the known loads to scale, the total stress in the members of the truss can be determined with very adequate accuracy. Those who are intrigued by this can easily be led to discover the reasonable assumptions that the summations of forces horizontally and vertically must be zero for coplanar forces in equilibrium, and that a figure composed of lines parallel to the action lines of these forces drawn end on end to scale must close. It is not necessary that all the men in the class master this additional coverage; there will be increased motivation to perform the construction accurately when it leads to a result that can be compared metrically with that of the other students. This is, of course, graphic statics. But a pre-view can give the stimulation of discovery and emphasize the problem-solving power of drawings. As another example we have:

1. Draw a straight line segment AB any length.
2. Construct AC and BD perpendicular to AB and any equal lengths. Draw CD.
3. Construct the midpoint K of AC and the midpoint L of BD. Draw KL.
4. Divide AB and CD into 10 equal parts and KL into 20 equal parts.
5. Number the divisions 0 to 10 from A on AB and from C on CD.
6. Number the divisions 0 to 20 from K on KL.
7. If now you connect any number X on AB and any number Y on CD with a line, it will cross KL at Z, the sum of the numbers. This is called a nomograph for $Z = X + Y$.

How accurate is your work? Do the sums check? Can you subtract 3 from 8 on this nomongraph?

Again to intrigue the quicker men and stimulate all of them to think and try to solve an unfamiliar problem, ask them to construct a nomograph for $Z = 2X + Y$, or

* Given at the annual A.S.E.E. meeting at Dartmouth, June 1952.

$Z = 2X + 3Y$. They need no further theory; the idea above can be adapted. As a real challenge, tell them that nomographs can be used for multiplication and division. Suggest $Z = 2XY$, or $Z = X^2Y$, as tests of their ingenuity.

Emphasis on Purpose

When studying orthographic projection, make the determination of necessary views and the selection of scale the student's problem. If possible give the students models to handle, measure and sketch with dimensions. If then the object is removed and the instrument drawing must be made from the student's own sketches, he will be stimulated to anticipate the predicament of anyone reading his drawing; it also emphasizes the purpose of the drawing to record information completely. Students can be asked to exchange sketches and make instrument drawings from each others sketches.

Several magazines publish monthly compilations of new devices and gadgets. Have each student select one and represent his selection with sketches and dimensions as he considers necessary to adequately describe the new article and the human need it fills.

Remind the students that some four legged devices have four wheels, some two wheels and some no wheels. What problems or requirements are best solved by each? Compile a list of free-standing devices on which you would prefer to have 4, 2, and 0 wheels respectively.

Visualization is an ability long associated with engineering. There is good reason to believe that those who can picture a situation have an advantage in solving it. Visualization of three dimensional objects or systems is a requisite for sketching. Give the students an isometric of an object with a compass indicating north, south, east, west, up and down. Then ask them to sketch isometrics of the object turned:

a. so that the given south face is west and the top is still top.
b. so that the given top is to the west and the given south face is still south.
c. so that the given top is the bottom and the given west face is still west.
d. so that the given bottom is to the south and the given east face is the bottom.

Finally have them judge which sketch best describes the object, or suggest a position that gives a sketch that is more descriptive than any of those required. Such an exercise supports the usual coverage of visualization and free hand sketching, but also involves flexibility and judgement.

Then again, we find that visualization is not enough. Can we be sure by visualization that there is a third plane perpendicular to any two given planes? Or a line perpendicular to and intersecting each of two given lines? Can we conclusively visualize that a brace cannot make an angle of 60° with both a vertical wall and the floor? Can we visualize the correct representation of an oblique conveyor perpendicular to another oblique conveyor? Can we be sure of the existence of a right triangle ABC whose hypotenuse AB is horizontal, bearing N30°W three inches long and whose side AC is frontal and 1 inch long? Can we determine the number of possible solutions visually?

Integration of Descriptive Geometry with Other Geometry

I am sure we all find engineering students well acquainted with the relations of plane and solid geometry. Thus descriptive geometry can be a problem-solving course from start to finish leading the students to see how several previously experienced geometric ideas can be combined to solve unfamiliar problems. I strongly urge that rather than building on an artificial set of rules or principles, we build all our solutions out of geometric relations with which the student is familiar. Thus, instead of being an isolated nightmare, descriptive geometry takes its place in an integrated pattern of plane, solid, descriptive, analytic and projective geometry, to-

gether with engineering drawing, an important application of all geometry.

The students know that if two points are on a plane, the straight line connecting them is on the plane; and that if a line is parallel to one line in a plane it is parallel to the plane. With just the conclusion in descriptive geometry that parallel lines have all corresponding projections parallel, the students should enjoy solving the problem of representing a straight conveyor with required bearing and parallel to the plane of a hillside represented with three points of a survey.

When the students know how to find the true length of a line segment in space, the problem of determining the distance from a given space point A to a given space line BC can be considered a new problem within their ability to solve. Certainly the most direct procedure is to connect A to B and C forming triangle ABC. Then by finding the true length of AB, BC and CA, they can form the true size and shape triangle ABC. The altitude from A to BC is the desired distance.

To stimulate thinking, students can be required to express verbally the strategy and meaning of their solutions to descriptive geometry problems. Certainly there should be no "blank-check" solutions that somehow grind out the answer if followed by rote. Each problem can easily be a new puzzle, interesting in its challenge rather than just another required example of this method or that method. Unannounced and intermixed problems that are impossible, keep the men on their toes and really startle the "turn-the-crank" boys who find too late that a minute's thought could have saved them the long struggle with a method that somehow didn't seem to work on the problem.

Realistic vs. Abstract Problems

Although realistic problem situations are often desirable, abstract geometric problems offer more possibility for analysis and logical reasoning. The larger number of variations in abstract problems give greater experience in confronting and solving unfamiliar problems. They also are an excellent medium for examining the solution and breaking it down to an itemization of the assumptions and basic relations used. Engineering problems are not truly solved until all basic simplifications and assumptions employed in the solution are recognized and their validity accepted. Experience in breaking down a solution into parts, evaluating and criticising those parts is an essential work-method listed by Professors Calvert, Hartenberg and Shelley. Also, an abstract problem dealing with points, lines and planes has application in many problems, whereas a specific realistic problem must be generalized before it can be applied in another case.

On the other hand, we and the students enjoy realistic problems. Realism that contributes to problem-solving ability is gained by the introduction of extraneous information in the statement of the problem, the listing of conflicting or incompatable criteria for the solutions or the indication of a problem situation in which the student is to act as a consultant, i.e., he is not to solve the problem but list the advantages and disadvantages of as many alternate proposals as he can. Give a driveway problem on a wooded slope and limit it to a straight driveway for ease of snow plowing. Let there be one path for the drive where no trees would need to be removed, and state that along this path construction costs would be 15% less per foot than along any other. However, arrange it so that the student finds that this treeless path is about 15% longer than the shortest possible driveway. The students can be asked to list related criteria and compare various of their own proposals. They probably will list maintenance costs, snow removal costs, grade for slipperiness in icy weather, accessability to town, convenience, visibility and safety of turn at the highway. Essentially the problem is a traditional one of a line perpendicular to another but these other considerations add interest and contribute to problem-solving ability.

There is the usual problem of a third pipe connecting two given skew pipes using 90° tees. Theoretically it is the problem of a line perpendicular to and intersecting each of two given lines. But add the information that the given two pipes cannot be removed except at great expense and trouble and ask how the third pipe can be installed with threaded connections without removing the given two pipes. At first the students may feel that there is no problem to it, and then after considering it, they may believe it impossible. Show them a standard union (coupling) and something about how it works. Soon the students will be busy determining the order of steps, cutting, threading, tightening 90° tees, this part of the union and that, and they will solve a problem that never existed before to their realization.

All in all we can stimulate and enhance problem-solving ability by orientating our emphasis in engineering drawing and descriptive geometry for increased relation to later engineering courses and graphic procedures that are essential in all engineering work.

In the News

Compilation of the 7th edition of **"Who's Who in Engineering"** has been in course for some time and the publishers report an exceptional interest and response on the part of the profession. This is attributed by the editor, Dr. W. S. Downs, in part to the service of the volume in past editions, but largely to the supporting activity of the advisory committee of Engineers Joint Council, the Societies, and the deans of faculties of the engineering colleges in recommending their eligible associates and graduates. Government agencies likewise have been helpful in listing key men for invitations to supply data, and individuals have recommended engineers of accomplishment. Indications point toward a high percentage of qualified engineer coverage.

There is still time for supplying new data or for revising records formerly printed. An intensive campaign to relocate engineers whose former addresses are no longer serviceable is under way and any engineer previously listed who has not received a communication regarding his record is urgently requested to address the publishers, Lewis Historical Publishing Company, Inc., 265 West 14th Street, New York 11, N. Y., for such service.

Undergraduate Training in the Use of Printed Materials in Engineering and Science*

By MELVIN J. VOIGT

Assistant Librarian, University of California †

Engineers, educators and librarians are agreed that if our schools are to produce competent scientists and engineers the library must somehow become more effective in undergraduate education in those fields. Various proposals have been made but a thorough analysis leads to the conclusion that progress in this direction is dependent on utilizing the classroom and teaching procedures themselves to give the instruction and experience essential to competent use of printed materials.

Librarians and educators have often discussed the question of the library's relation to the engineering student. The common criticism always seems to have been that no matter how good the libraries were, engineering students were not using them. Sometimes the blame was put on the student, sometimes on the faculty, sometimes on the library, and occasionally on the inherent nature of the engineering curriculum. While we hardly wish to encourage it, we must admit that engineering has and can be taught without a library. How well, is, of course, another question. Graduating engineers have been known to proclaim that in their four years they never entered their institution's library. This may be quite true, and it may also be possible that these same students graduated with high honors. Until a few years ago, at least, traditional teaching methods employed in many engineering schools gave the student little need or incentive to use printed materials other than his textbook and possibly a handbook or two.

One cannot help but wonder, however, how these graduates managed without this experience when they went into professional life. How many hours or months they spent solving problems by prescribed formulas and rules when these same problems could have been answered in a few minutes by making use of someone else's experience as reported in print. How many years of training it took to make up for this deficiency in their education.

With the present emphasis on the social sciences in engineering education and a changing conception of teaching procedures, it is unlikely that a student can get very far in his educational training without using libraries and through this use, learning something of the value of printed materials and their contribution to a well-rounded education.

There is, however, a distinct possibility in some schools and in some departments in others that the engineering student may yet come out with his engineering degree but with little or no experience in using printed materials in his own subject field. Consequently, he will have little realization of the importance of this material to his every day professional problems, and no ideas of where to turn to answer the questions which arise outside the realm of the formulas and rules which he expected would be infallible.

It is the intention here to point out the importance of undergraduate training in

* Based on a paper presented at the 59th Annual Meeting ASEE, Lansing, June, 1951.

† Formerly Librarian, Carnegie Institute of Technology.

the use of printed materials in the students' major subject fields and to discuss methods by which such training can be accomplished.

New Educational Procedures

Recently adopted educational procedures make the consideration of this problem imperative. Engineering education is moving away from textbook-lecture-memorization patterns to methods leading to analysis of problems and their solution on the basis of knowledge of fundamentals and their broad applications. If printed materials and their use are neglected in engineering schools practicing an educational philosophy of this type, the student may be left weaker in his potential value as an engineer than when his stock in trade was a series of set patterns and formulae. I have attempted to indicate this in the following four points which illustrate the new factors in the educational philosophy as they affect the use of the librarian's stock-in-trade, the printed page.

(1) There is less emphasis on learning and using specific formulae and methods; therefore, if the student is to work efficiently in school as well as in professional life, he must be provided with the ability to find these formulae and methods in print, as well as with the ability to develop them for himself.

(2) There is greater emphasis on acquiring the background and ability which will lead to modification of methods, formulae, materials and apparatus to fit altered situations; therefore, the student must be proficient in discovering the factors which will best yield themselves to modification and the means which have or can be employed in their modification. (This is in contrast to the older conception which depended entirely on the use of standard, or learned techniques.)

(3) There is greater emphasis on building on the experience of others; therefore, the student must become efficient in finding as well as in making use of the reports made by his predecessors in the field.

(4) It is believed that the approach used leads to greater efficiency in reaching the solutions to problems, due to clearer analysis of the factors involved; therefore, it is possible to evaluate and make greater use of the short-cuts and partial solutions provided by the experience of others in working through the increasing complexity of scientific concepts and procedures.

If these premises are correct, the library cannot be considered as something extra in engineering education, but must become an integral part of the teaching program. The adequacy of the collection and staff will be determined by the success or failure of individual courses and programs as they are carried out with the educational and library purposes unified toward a common goal.

How then can the student receive the training he needs in the four short years of undergraduate education? In the first place these objectives are not entirely new. Even when not specifically expressed they have often been carried out, at least in part, in many engineering courses.

Librarians and engineering educators will find on investigation that there is a good deal more training of this kind going on in their institutions than they realize. Such training is not being done in special classes on engineering literature or in orientation programs, but it is being done in many classrooms in many departments. And experience indicates that only in this way can it be done effectively. The librarian's part, therefore, is not necessarily an active teaching part in such a program. More important on his part is his status of coordinator and, in some cases, activator. For while such training is being carried on, it remains scattered and in most cases uncorrelated.

The librarian working with each department can help plan and carry out a program which will insure that every

student of that department becomes familiar with all of the types of printed materials which are useful in his particular field. In a four-year program he will then have covered the same ground he might have in a concentrated course. But by bringing this contact with the literature directly into the classroom, the student learns directly of its usefulness. It is not something tagged on for his "cultural development" in which he takes, at best, a half-hearted interest.

This problem of giving the engineering student the training and contact with the literature of his own field which he needs for success in and after his formal training is primarily a problem of the upperclassman. In the freshman, and probably in the sophomore year, the student is not ready for extensive contact with these materials. It would be difficult to relate them to his current studies, and he would not realize their importance.

Early Familiarity with Library Materials Important

However, it is important that the students become familiar with library materials and their use before they reach upperclass status. A knowledge of how to use card catalogs and reference tools, some understanding of bibliographic organization is necessary on a general basis prior to specialized training if the latter is to be effective. Much has been written on methods of orienting freshmen in the use of the library, and many schools have worked out effective techniques which would be unsuitable in other situations. At Carnegie this phase of the training has been correlated with the English and history basic courses early in the freshman year. These and other humanistic and social studies courses which follow bring the student to the general library week after week, so that the knowledge and experience gained in this program is constantly and increasingly useful and serves well as an introduction to the more specialized library usage of upperclass years.

Specific methods of carrying out the desired objectives relate primarily to a program of training the junior and senior engineering student in the use of printed materials in his own subject field. Obviously more can be done in some departments than in others. It takes a will to do by the department as well as the library. Success in one department, however, furnishes live ammunition to use with others less enthusiastic.

Usually the use of technical sources of information can be practiced to some degree in all departmental courses in connection with regular assignments. However, the nature of the material often dictates that certain courses carry a larger part of such practice than others. Especially useful for this purpose are the so-called seminar courses used in many departments to give students experience in verbal expression.

The librarian's only direct contact with a training program may appear at this point. At an early meeting of such a seminar the librarian can profitably use one period to introduce and give basic instruction in the sources of technical information available (handbooks, textbooks, and periodical literature). The use of the library catalog can be reviewed and bibliographic and abstracting and indexing services needed to locate information needed in making seminar reports can be introduced. Throughout the seminar it is possible to make increasing use of library resources. Such a course which has as its primary purpose the training of the student in oral communication and the orderly organization and presentation of technical matter should make constant use of both older and newer literature of a serial nature, and is ideal for training in the use of abstracts and indexes, and for experience in utilizing periodical information. Assignments can insure that the student progresses gradually from semi-popular periodicals to transactions of technical societies as sources for his seminar reports.

Many departments make use of a senior thesis or problem One of the seminar talks may be based on plans for

this thesis, following a survey of the experience of other investigators as revealed by a literature survey. This may be followed toward the end of the year by a presentation of the results of the thesis and an interpretation of it in the light of previously published data or experience.

The selection of material for the seminar talks and theses should be done in interviews with a departmental advisor who can profitably give additional practical advice on methods of finding suitable material in the library.

In departments in which seminars and senior problems are not a part of the curriculum the opening wedge may be more difficult to drive. However, it would be rare to find a department where some junior level course and its instructor would not be interested in providing the start needed. Subjects such as organic chemistry are perfectly adapted to such introductions. A recent final exam in one course began this way:

"In what book, journal or other reference source would information on each of the following subjects most probably be located? Give only one reference source for each subject; if you cite more than one source, only the first one named will be graded. Do not cite abstracting journals."

It is obvious that students in this course have had an introduction to scientific literature.

A good example of a course well-adapted to these objectives has been a senior course in metallurgy which is planned to teach the student to solve engineering problems through the application of the basic science and engineering learned in earlier courses together with engineering technology from printed sources. Teams of students divided as a "plant metallurgist," "materials engineer," "production manager," etc. present two case studies during the semester. One study is on the selection of a material and one on the selection of a process for a product. Here library materials are combined with instruction and outside aid in a combination common to industrial procedures. The library is used to learn the nature and duties of the students' particular assignment as well as the properties of the materials, features of the process, etc. pertinent to his part in the engineering analysis and decision. This information is combined with that obtained from letters or interviews with men in industry and instructors and research personnel on the institution's staff.

This course presents an opportunity to introduce the student to a wide variety of printed source materials. The instructor constantly brings out new types of materials and points out their usefulness for particular purposes. Among these are handbooks and treatises, both general and specific; trade catalogs, and data sheets; government specifications and reports; and reference works on standards and testing. Periodicals, abstracts, and indexes are used in a variety of situations leading the student to determine their varying usefulness for particular types of information. Because of their limited experience, the students must base their engineering decisions almost entirely on data and methods gleaned from printed sources and applied in situations which are new to them.

Make Course Practical

To make the course as practical as possible, real cases are used to demonstrate the printed materials most useful in particular situations. The primary sources used by a metallurgical engineer in an automotive firm, those most important to an engineer in the research and development division of a steel manufacturing company, those used by a materials engineer in an electrical products firm, and finally those most useful to a metallurgical engineer in a large government arsenal are listed, discussed, and investigated. These sources were prepared with help of engineers actually in these various positions.

In many courses it is possible to stress the importance of association with other engineers in technical societies. The tie between these personal associations and printed materials has often been over-

looked by librarians and it is certainly one which needs to be understood and practiced by the engineer and scientist.

I have described briefly a few specific courses which lend themselves most easily to the purposes of library identification with undergraduate teaching. Others must also be used to insure a complete coverage of printed sources of information. A few examples will be sufficient to show the type of problem which may be inserted at a variety of points in the curriculum.

(1) Students may be assigned problems for which complete data (e.g., physical properties) are not given, and the student must find sources for the data and convert it to proper units.

(2) Students may be required to obtain production statistics and current price comparisons for common materials—metals, chemicals, etc. from unspecified library sources.

(3) Instructors may inform students that certain recent technological developments will not be covered in lectures, but that the student must learn of these developments from current publications and will be held responsible for this information in quizzes.

(4) Principles of abstracting may be introduced by requiring students to write one-page abstracts of good, unspecified articles on particular subjects.

It is hoped that this description of a few of the many possible procedures will give some indication of how the library may identify itself with engineering education. Often it is necessary to start in one department and it may be difficult to carry such a program to another. However, if one department is found in which there is a real interest, a start can be made which will make possible gradual expansion to other departments. Experience indicates that it takes a good many years to show much real progress in some departments. A program such as this cannot be started until the curricular program is put in step with the newer concepts of engineering education, and this in turn may depend on changes in leadership within the department.

The rewards, however, are great, for a well-coordinated training plan, coupled with a good, active library collection, a well-trained staff and a well-planned library will insure that engineering education, graduate and undergraduate, has made the library an integral and essential part of the student's preparation for a useful professional life.

Communications—The Responsibility of Management and the Management Engineer*

By ALEX W. RATHE

Associate Professor of Management Engineering, New York University

The Tower of Babel

In the assignment of my topic, the Chairman has bracketed together three things: Communications, Management, and the Engineer. These three form a tripod; they have done so from time immemorial.

Already in the most revered of all records in the history of mankind, the Bible, there is a well-known account of the interdependence of these three. It is the tale of one of man's first large-scale engineering projects, the construction of the Tower of Babel, whose top was meant by human foolhardiness to reach unto heaven. The undertaking was stopped cold when The Lord gave each man a different language so that project management could not stem the chaos which resulted at once from the people's inability to communicate.

Since then and through all centuries, confusion and defeat has faithfully followed whenever communication has failed between persons.

Communication in Human Life

Building the lines of communication has traditionally been an engineering task. In the broadest sense of human relations, the shape of world affairs has been changed, often in near-revolutionary fashion, whenever progress is made in communications.

World-shaking events were forecast in the developments which led from stage coaches to jet airliners, from carrier pigeons to facsimile transmission, or from the pictures which the Neanderthal Man drew on the walls of his cave to printed matter to radio to television.

On the narrow scale of management, communication has been of similar, overriding significance. This is so because management's sole "raw material" is people. Whatever management does, it accomplishes through people. And the only way to energize, motivate or activate people, to spur them on or to hold them back, is by communication.

Again, it was primarily the engineer to whom has fallen the task of providing these channels of communication. He has helped to furnish management with quite a number. Each and everyone of them shows the imprint of typical engineering thinking and approach. Together, they form the foundation, structure, and pathways within which business, commerce, government, schools, and any other human pursuits are directed by their managements. Here is a brief glimpse at the vast variety of equipment in management's arsenal of communication.

The Manager's Communication Center

The basis of all activity is provided by Company Policies. In them, the execu-

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tives lay down general principles which will, under the prevailing circumstances, best guide operations to the desired objective. Policies thus give a broad "fix" on the target, sound the keynote for everything that goes on.

To mention one example: After determining that it would be most advantageous in its particular situation for Chevrolet to market its automobiles through exclusive agents, this principle was laid down as part of its sales policies which have since governed the distribution of every car produced by this General Motors Division.

Policies—for sales or any other type of work—must be reliable, unfailing, and unambiguous communications if they are to be successful in directing many and often widely scattered persons uniformly over a period of time.

Another important contribution which the engineers have made to managerial communication is Organization. This phase of planning work designs the framework within which all operations are carried on. It determines what tasks have to be performed within the firm and distributes them over the personnel in the enterprise.

Organization weaves a pattern of relationships between departments and groups, plants and offices. It is a managerial circuit diagram. Through it, we attempt to convey to everybody one and the same impression of what his job is so as to avoid uncertainty as to just exactly who is responsible for doing what. Time and again, major difficulties in organization have been caused by the problem of expressing this functional arrangement in clear, readily understandable terms.

Procedures are a third message carrier. They give operating instructions in detail. Just as procedures govern registration and many other activities in Colleges, so do purchase, payroll, inspection, engineering change, and innumerable additional procedures serve as transmission belts in industry and commerce. They get data, information, facts, ideas, decisions, etc., from one quarter to the next.

A collection of managerial communication vehicles would further include Statistics and Reports; Interviews; all Records; Orders and Instructions; Board Resolutions and Committee Minutes; etc.; in brief, every single expression—be it oral or written—from a two word "Go Ahead!" to a 300 page manual. Whatever their specific form, purpose or appearance, managerial communications are the connecting link between executive thought and operations.

They link people, steer work, and cause every single move in the engineering drafting room as much as on the factory floor, in the sales show rooms, on warehouse platforms, in mine shafts, airport control towers, the Big Board in Wall Street, or the halls of Congress. Communications are the warp and woof of every fabric in any joint human endeavor.

They are as potent within the confines of one firm in connecting its own people with one another as they are powerful in transmitting ideas beyond the factory plot to the folks outside. A manufacturer's Instruction Manual for the use or installation of his product, or Advertising, and Public Relations are examples of the many communications with which management attempts to span a bridge to its customers, to the community in which it is located, or to the entire nation.

The Building Stone of Managerial Communication

It is merely an outward recognition of the difficulties in communicating that just about every profession has developed a terminology of its own to take care of specific expressions more adequately. The seemingly hieroglyphic characters on a physician's prescription are very plain to the initiated. The layman may be baffled by legal phraseology yet the lawyer finds it a boon to his work.

That "deferred expenses" have actually been paid ahead of time is perfectly lucid to the accountant although perhaps a

trifle confusing to the outsider. And we engineers have gone further than most other groups by inventing an entire language of our own, that of engineering drawings.

In contrast, management's youthfulness as a profession, has as yet prevented such developments. It just uses the language which is spoken around it —or at least it hopes it does.

This is why all the various types of managerial communication have a very common building stone: words, everyday words. Good communications are as reliable as dial telephones; we reach the right party, automatically, if we dial the right number. The problem is to find the right word. And that is quite a problem.

Even a very slight difference in words can cause a vast difference in their reception. We could test this rather readily if we were to call a lady a "kitten" or a "cat," a "vision" or a "sight."

But although we may choose the right words, we may use too many. That has been another frequent barrier to effective communication. The Gettysburg address took 266 words, the Ten Commandments 297; but the new ruling of O.P.S. to reduce the price of cabbage required 26,911.

Much more bothersome is the vexing dilemma if the same word conveys a different meaning to different people. "It is not necessarily true," said Mr. Justice Holmes, "that the word 'income' means the same in the Constitution and in the Income Tax Act. A word is not a crystal, transparent and unchanged; it is the skin of a living thought; it may vary greatly in color and content according to the circumstances and the time in which it is used."

It goes back to this Supreme Court decision that we have to pay income tax today. This illustrates, if I may impose upon the generosity of your imagination, the significance of the meaning of one word, in different surroundings, in terms of many hundreds of billions of dollars.

The same can be shown, though, in terms which are more suited to our professional situation: A 12″ television screen was called "giant" just fifteen months ago; it could hardly command that designation today. As you know so well here in New England, Potato Grade No. 1 is second because "U. S. Fancy" comes first; Grade No. 2 is fourth because "U. S. Commercial" stands between "one" and "two." The newspaper which carries the words "Thursday—Morning Edition" on its masthead, came out at 8:00 o'clock at night on Wednesday.

It is then not just the words which count but the meaning which they have to the people who use them. I should say more distinctively, it is the meaning which the recipient of a message reads in it that determines the effectiveness of the comunication.

The problem in communications is therefore one of selecting the right words in terms of the receiver. We must make certain that our policies, organization, procedures, orders, and what not, carry to the addressee the meaning which we intend for him to find in them.

Alliance between Technical and Living Sciences

And this task sends the engineer into realms in which he must obtain assistance from other quarters. It is still the technical man who builds management's communication network today. But when it comes to its use, the executive finds his management engineer deeply concerned with the knowledge of brother professionals.

It is primarily the task of effective communication that has brought the student, teacher, and practitioner of management to the wells of information of Psychology, Sociology, Anthropology, Semantics, Philosophy, History, or other disciplines. What has already been achieved in the particular field of communication is perhaps most significantly indicated by the magnificent writings of Dr Norbert Wiener of M.I.T. on "Cy-

bernetics," itself a composite of technical and living sciences.

Forward-looking management wants all pertinent experience applied judiciously to the solution of its problems. This poses a tremendous challenge for the Management Engineer whose ambition Dean Saville once described as "to find in the crucibles of business practice ever-growing opportunities to prove that he can make a weighty contribution toward ever-greater utilization of natural as well as of human resources."

This means that we should use our engineering know-how to the limit but that we have to alloy it with the heart and feelings whose lack Gantt deplored more than 30 years ago. In communication, as anywhere in management, it is the people that count.

That recognization has come to us in management in these crucial days—crucial for world peace but also crucial for the future of management—which are sometimes called the "Atomic Age." It is perhaps more than a coincidence that it was the thinkers, pioneers, and practitioners of the Natural Sciences who found that the earth's most powerful source of energy is released when Nature's smallest building stone, the Atom, is set free.

Equally unfathomable strength will become available when the Living and Natural Sciences team up in their service to Management. Joined together, they will unshackle, from bonds of wasteful practices, degrading indignities, and distorted communications, the resources of Life's most elemental building stone, Man.

Sections and Branches

The nineteenth annual meeting of the **Southeastern Section** of the ASEE was held at the Louisiana State University at Baton Rouge on February 26, 27 and 28th.

The first day was devoted to a meeting of the Engineering College Research Council. On the following day, the meeting was addressed by W. R. Woolrich, President of the Society. L. E. Grinter gave a progress report on the activities of the Committee on Evaluation of Engineering Education. A paper on the "Historical Background of Engineering Studies" was presented by N. W. Dougherty. Other speakers included W. J. McGlothin, who presented a paper on "The Progress and Promise of Regional Education in the South," and H. H. Armsby, who gave a report on the engineering manpower situation in the United States.

The following officers were elected for the year: Chairman, J. R. Cudworth; Vice-Chairman, H. V. Flinsch; Secretary-Treasurer, L. E. Schoonmaker.

Some Applications of General and Statistical Mathematics in Industrial Engineering*

By W. GRANT IRESON

Professor of Industrial Engineering, Stanford University

1. Purpose of Paper

The purpose or theme of this session was established by Everett Laitala in his original correspondence with the speakers on this program as being the need for critical study of the status of industrial engineering. The thinking behind this program is that industrial engineers have been relying upon qualitative analysis of problems when quantitative analysis is needed. There is also the underlying idea that greater use of mathematical techniques will elevate the status of industrial engineers within the professional family.

This paper attempts to help clarify the part that mathematics now plays and can play in the industrial engineering profession. It also attempts to establish some areas in which quantitative measures may be found and used in the problems of the profession.

Dr. John M. Clark of Columbia University, has captured the essence of these questions in two of his verses, known as "K.B.'s":

When firms grow big with many parts
They learn communication arts,
And bosses, to avoid distraction,
Have formulas to guide their action.

If business seeks its greatest gain,
Can mathematics make things plain
When peering through the misty curtain
At prospects that remain uncertain?

* Paper presented before the Industrial Engineering Division, ASEE, at Dartmouth College, June 25, 1952.

2. What is Industrial Engineering?

No definition of industrial engineering has been written that satisfies a majority of those engaged in what is loosely called industrial engineering work. It is therefore necessary to clarify the meaning of the term as it will be used in this paper. I have chosen to define industrial engineering in two ways: first, in terms of special skills and techniques, which I believe is the common meaning, and second, in terms of functions of a higher order, which is the way I think we should define the bounds of the profession.

Definition by means of special skills and techniques indicates that a person is an industrial engineer if he practices in one or more of such fields as:

1. Motion study
2. Time study
3. Production planning
4. Materials handling
5. Plant layout
6. Cost accounting and budgeting
7. Quality control
8. Estimating
9. Engineering economy
10. Job evaluation and merit rating

These are jobs which can be learned in ordinary trade schools or on the job in the industrial plant, and can be performed with some success without broad, general engineering training.

Industrial engineering as defined by functions of a higher order involve such activities as:

1. Industrial and production management;

2. Various control functions involving analytical ability;
3. Plant and production engineering, including the direction of specialized work of other branches of engineering and involving broad engineering knowledge;
4. Long-range policy planning;
5. Research and development of new techniques that can be simplified for use at the skills level.

It is obvious that such functions of the higher order require broad, yet intensive training in the whole range of basic engineering subjects, including mathematics, plus analytical training in the specialized skills of industrial enginering activity.

3. *The Problems Encountered Are of Two Corresponding Levels*

The problems of industrial engineering represent two very different levels of mathematical accomplishment. The mathematics employed in the quantitative solution of problems in the specialized skills and techniques seldom involve anything more complicated than arithmetic, algebra, geometry, elementary calculus and statistics. The methods of solution at this level are generally prescribed by the practices of the employer and stress the numerical solution without questioning the soundness of the method. Accomplishment of routine daily tasks is the principal objective, which allows little or no opportunity for creative effort or the development of new techniques. The emphasis is upon following procedures and understanding the relationships of the divisions of an organization.

Secondary consideration is given to the solution of problems in related fields of engineering. Since the practicing industrial engineer must work with mechanical, electrical, and chemical engineers, he should be able at least to understand the numerical solution of problems in these areas. We have recognized this need by requiring industrial engineering students to take courses in the fields of thermodynamics, machine design, electrical engineering, electronics, etc.

Some of the common problems encountered by the industrial engineer at this level may be enumerated:

1. Setting time standards from time study—involving arithmetic and, in some cases, simple algebra;
2. Calculating economic lot sizes for production—involving the first derivative of a simple equation of total unit cost;
3. Establishing natural variation limits for a quality characteristic from a controlled process—involving a simple statistical technique and ordinary arithmetic;
4. Designing machine elements, conveyors, power systems, or simple trusses—involving, at the most, integral calculus.

You can see that these problems, which are the most difficult of the common industrial engineering problems of this level of activity will not tax the mathematical knowledge of any third year university student. In most cases formulas are employed so that a person can obtain the numerical solution without even understanding why he is using that particular formula. This is one of the reasons why we, as industrial engineers, have been subjected to considerable criticism. For numerous reasons both other engineers and businessmen hold on to the idea that this is the limit of the industrial engineering profession. I propose that this is no more representative of industrial engineering than work on the detail drafting board is representative of the mechanical engineering profession. These activities merely provide the training period for young industrial engineers who should be reaching for something higher. I think that it is safe to state that one who continues at this level for a lifetime is not a professional industrial engineer but a technician.

4. The Second Level is the Goal

Industrial engineering should be measured by the second level of accomplishment. Here mathematics becomes considerably more important and presents a real challenge to any of our current engineers. Differential equations, probability theory, statistics, statistical inference and the games theory are essential to the numerical solution of these problems.

The nature of industrial engineering problems of this level is unique in several respects. The typical problem requires the choice of one of a number of alternatives under these special conditions:

a. Information is incomplete and cannot be correctly or completely ascertained in a reasonable time or at a reasonable cost;
b. Considerable risk is involved with serious consequences resulting from an improper choice;
c. More than two parties are interested in the solution;
d. The outcome of the problem is likely to be affected by strategy and bluffing;
e. The solution should be quantitative; qualitative solutions are generally not acceptable and are little better than guesses.

It seems obvious from this analysis that the nature of the problems dictates the use of probability theory and games theory as the basis for solutions, with advanced calculus, differential equations and matrix algebra being employed in the derivation and development of suitable equations.

Operations Research, or its counterpart, Industrial Research employing the same methods, will play a large part in the development of concepts of industrial engineering. Morse and Kimball have defined operations research as "a scientific method of providing executive departments with a quantitative basis for decisions regarding the operations under their control." The authors stress the fact that the operations analyst does not make the decisions; he is free of that responsibility so that he can look at the problem objectively and merely determine the prospective results of the various courses of action. We generally think of this method as being a highly mathematical one, but the truth is that some of the most spectacular results were obtained in the military application of these techniques without the use of a single equation. The operations analyst has two principal problems: first, he must determine what is the real problem for which a solution must be sought; second, he must find the pertinent data on which he can plan his attack on the problem. In military practice the analyst had one great advantage which is not usually present in industrial operations: he had no other duties and could devote as much time as necessary to thought and analysis of the problem. This is an important factor to be observed as far as possible in industrial applications.

Operations Research methods can be employed to find the problems requiring solutions and to evaluate the results of the various alternatives. Our old standby, engineering economy, can and will play an important role in this matter.

In operations research it was frequently possible to design experiments which would provide the necessary data in the shortest possible time and with the smallest possible number of experiments. In other cases, the urgency of the situation made an approximate solution based upon incomplete and inadequate data more valuable than an exact solution at some later date. In still other cases sufficient data were available at the time the problem was recognized and defined to permit a rapid solution. It seems probable that these three conditions will be encountered in industrial engineering problems. Furthermore, just as in operations research, it will occasionally occur that no controlled experiments can be run because the actions of the other person or concern may vary from time to time

without the fact or the extent of the variation being known.

War time experience indicated that almost any research scientist who had become disciplined to think clearly, analyze thoroughly, seek underlying principles and get down to the fundamentals of a question could be successful in operations research. High level members of the Operations Research teams have stated that scientific training in any of the disciplines was sufficient, and indicated that it is doubtful if persons can be trained specifically in operations research methods in colleges. This would lead us to believe that sound training in the subjects enumerated at the beginning of this section would be about the best mathematical training that we can give the prospective industrial engineers for this phase of the work.

On the other hand, it is possible to give direct training in the theory of games, which, to me, appears to be the most important mathematical tool for future industrial engineers. There are some excellent published works on both the theory of games and its application to economics and industrial situations. The nature of the higher level problems, as described earlier, is complicated by the fact that the industrial engineer is attempting to make decisions regarding events that will occur in the future, and furthermore, the results will be influenced not only by this decision but by actions of competitors, legislative bodies, unions, and even the customers of any concern. The shrewd analyst can attempt to associate the possible actions with some probability of occurrence and formulate an equation by which he can obtain the maximum gain. Each event in the development of a situation can be treated as a variable which will describe the actions of the participants. In addition, coalitions of participants involved may develop and strategy will be employed by participants or coalitions of participants to gain their point in the problem.

As an illustration of a recent occurrence that fits into this presentation we may use the steel wage dispute. I have become very interested in trying to analyze the actions and counter-actions of the participants in the steel wage dispute in terms of the games theory. There were more participants in that "game" than might at first be realized. Of course the two original participants were the steel companies and the union. Very quickly the federal government came into the game as a paricipant through the imposition of price and wage controls. When the President's Wage Stabilization Board recommended a wage settlement figure the Government actually became two participants with one branch forming a coalition with the union. The public was a somewhat silent participant all of the time, but did not actually appear in the "game" until the court proceedings started. At the time of this writing the dispute has not been settled, but it is not difficult to apply some rough probabilities to the possible events that can occur and determine the approximate course of events. Without a doubt, the industrial engineers and managers of the steel companies could have set up this problem as a theory of games problem with five participants and of the "non-zero-sum" type.[2] I feel quite sure that with the information available to the companies the "moves" could have been planned well in advance of the actual events, with the probable outcome fairly well predicted.

Some more frequent industrial problems which are subject to this type of solution are:

A. Allocation of materials, labor and productive capacity to the several products of the concern in periods of scarcity.

   Any of you who have been following the electrical appliance industry in recent months will appreciate the magnitude of this problem. The effects of economic pressures on the consuming public, the saturation of the market for some types of appliances, and the limitation on the use of material and labor have

caused many companies to search for the proper balance of radios, television sets, ranges, refrigerators, laundry equipment and home freezers, in order to maximize profits. The results obtained by each company will be affected by the actions of all of the competitors, credit restrictions, promotional programs and the availability of the various products.

Along this line, one of the amazing current conditions in America is the shortage of Cadillacs.

B. Rate of manufacture by periods or seasons relative to probable sales.

All of us understand the desirability of stabilized production and regular employment, but few companies have attempted to solve the problem except by the most simple means. I believe that operations research and games theory will provide a more realistic quantitative solution.

C. Establishing order-points, maximum inventory and purchase quantities for minimum total cost.

Our economic lot-size formulas have attempted to solve the purchase or manufacture quantities part of the problem, but the order points and maximum inventory points have largely been set by guess.

D. Planning a capital investment program for industrial expansion.

The advisability of long-term commitments of capital funds depends upon a large number of factors, many of which can only be predicted and over which the company has no control. Success or failure is likely to hinge on how these future conditions are considered in arriving at the capital expenditure budget.

E. Decisions regarding incentive wages and/or profit-sharing programs.

This is a very good problem for this method of attack since the participants in the "games" can readily be identified and the interests analyzed. This is the sort of problem in which it is possible for all participants to "win," but the company assumes most of the risks in order to obtain certain advantages over its competitors.

F. The development of new techniques which can be applied by the technicians in the plant.

The development of statistical quality control and acceptance sampling are examples of how relatively simple techniques have been developed from very advanced mathematical concepts.

These problems are being solved by methods that rely more upon guesses, hunches, and the art of management which comes from experience than by scientific methods. We should be giving more thought to ways of expressing these problems in the form of equations which will reduce the risk of improper decisions.

5. *What Shall be the Objective of the Mathematical Training of Industrial Engineers?*

The technical problems of the lower level are fairly well covered in our accredited curricula within the framework of currently accepted methods. Progress is being made by many men who are examining these methods critically and designing new and more acceptable procedures. However, we can anticipate rather slow adoption of improved methods for its means retraining a vast number of practicing industrial engineers, but we can contribute to the adoption of improved methods by introducing our students to these methods while they are in school.

The problems of the higher order of industrial engineering will require additional consideration. Very few of us are currently prepared to handle them and

only by becoming aware of the applications of higher mathematics to these problems and learning about them ourselves can we hope to improve the situation. In the meantime we will have to struggle along as best we can, making good use of the few consultants, mathematicians, and statisticians who are prepared to give aid in the solution of these problems. Our aim should be to develop over the next ten to fifteen years a new concept of industrial engineering and begin preparing our students to take their places in the larger field by improving the mathematical program within our curricula.

6. Conclusions

In conclusion it seems obvious that the professional status of industrial engineering demands these things: (1) We must develop the mathematical concepts of industrial engineering; (2) We must train and develop competent persons in the profession; and (3) We must admit that we have not been as objective in the past as we might have been and determine to learn to use all of the tools available to overcome the adverse and unjustified criticism that has been leveled at us.

We cannot simply say, "Yesterday we were pseudo engineers, but today we are going to use higher mathematics and be truly scientific." We are dealing in a large part with human nature and human nature cannot be reduced to a few simple formulas. We must develop our science over the years, very much as mechanics or electronics have been developed. By making use of mathematical tools to analyze industrial engineering problems we can help remove the guesswork of industrial management and really approach that aimed-for goal, scientific management. If we do make proper use of these mathematical tools I do not think we will find ourselves in the situation described by Dr. Clark in another of his "K.B.'s":

To put the calculation into "calculated risk"
Write unknown future quantities as terms in an equation
With estimated average and range of deviation;
Feed into an "electric brain" and turn the proper disc,
And if the fates are not unkind in times of strains and stresses,
You may score a trifle better than the man who simply guesses.

Reserve this date . . . .

June 22-26, 1953

ANNUAL MEETING

UNIVERSITY OF FLORIDA

GAINESVILLE, FLORIDA

Stronger Engineering Graduates*

By GILBERT E. DOAN

Research Department, Koppers Company, Inc., Pittsburgh, Pa.[1]

It is well recognized that after the four-year round of courses with specialists at college whatever life philosophy the student may have brought from his home has lost its unity. The resulting disunity of thinking leads to disunity and confusion of spirit. This confusion results in weak and uncertain graduates where strong adaptable leaders are needed. His ideals and convictions *should* be shaken basically by the specialists. But before he leaves college some aid should be given him to re-form at least a tentative life philosophy based on reason and justice. *Most men should leave our colleges with a clear and worthy view of life.*

The German professors were the world's best specialists, but they turned a deaf ear to the student's professional, civic, social, and ethical problems. As a result, these students, denied guidance by their natural leaders, followed eagerly a man who offered them definite answers and positive guidance. His name was Hitler and he led his country to ruin.

Specialization and research must remain and grow both in science and in the humanities. But we must also turn out consciously integrated graduates dedicated to a life of justice, reason, mercy and truth. This is our heritage from the English universities. This integration should be the culminating phase of a man's education. It is the creative answer to subversion of all kinds.

A Solution

The first step necessary for most students is to bring their scattered and fragmentary "courses" of study together into a focus. The student's own problems provide a suitable focus—war, communism, the welfare state, and labor With just a little encouragement he can see the need for working out a rational life view to face the world intelligently. The specialists who have taught him the individual courses pay little or no attention to this need

We have provided good intellectual fare in science and the humanities, taught by competent specialists. Then we have turned our attention to extracurricular activities including athletic and social life, hoping the boy would make his own synthesis. Thus, the final step of the *intellectual* program has been omitted. We have overlooked the influence of the Oxford tutorial in aiding young men to evolve a rational life view.

This synthesis must be encouraged in small discussion groups, or in individual tutorial hours as has been the practice at Oxford for so many years. Indoctrination, of course, must be despised as abuse of students and ultimately ineffective anyway. A friendly atmosphere must prevail. Opposing viewpoints must be represented clearly. The students must be permitted to choose the topics of discussion, and the world must be looked at through their eyes. Of course, no teacher feels that he is fully competent to meet this demand (neither are the Oxford dons) but we must satisfy this hunger in students for a rational outlook with what we have to give them and not send them away empty

* Reprinted from *Mechanical Engineering* for November 1952, pages 877 and 908, with its permission and that of the author.

[1] At the time this paper was written the author was professor of Metallurgy at Lehigh University, Bethlehem, Pa.

simply because we are not "experts" in the field.

Results of an Experiment

After conducting a discussion of this kind once a week with a group of seniors in metallurgical engineering who elected this course last year, I have read their term papers. The papers showed the following features:

1. Each student is consciously constructing his own philosophy which he knows will change as he matures.

2. The philosophies are rudimentary and even shallow in spots, but a vision has been caught of what a rational life view means.

3. Not a single man felt he had been subjected to indoctrination but rather that he had been warned against it. Considerable diversity of views prevailed on any given topic.

4. Religion enters these philosophies only as a general background and in most of the papers is not mentioned.

5. A sense of social responsibility has been accepted as justified. (This alone is an accomplishment.)

6. The eight students who elected the course are enthusiastic about it All have elected the sequel for the next semester. Several remarked that this course should be required, not only for all engineering students but for all college students.

7. Several books by broad thinkers have been read by each man from the list: Eddington's "Nature of the Physical World," Sinnott's "Cell and Psyche," Lynd's "Middletown," Lilienthal's "This I Do Believe," Montagu's "On Being Human," Polanyi's "Science, Faith, and Society"; articles such as those on labor in *Fortune Magazine* and others have been read and discussed, thus opening new doors for the student.

8. The material learned in other courses such as science, economics, government, history, politics, international relations, philosophy, and biology have been related to the outlook of an engineer as he enters his profession in society, or at least he has seen in numerous instances that these fragments of knowledge *can* be related in one man's mind and should be related in his own.

9. Specific positions (admittedly temporary) have been taken with respect to the student's problems; the welfare state, private enterprise, communism, war, career ambitions, labor, and personal responsibility.

10. Highly developed technical philosophies have not been stated by the students nor taught; but each man has caught a vision of a rational outlook to which the fragments of life and learning can be related. One student remarks that most people never seem to reach a rational philosophy in an entire lifetime, and he is glad that he has at least made a start.

11. These students have become personally acquainted with the solutions, attitudes, and interests of at least one of their teachers, and one who has taken the trouble to show them clearly the directly opposite view to his own, thus breaking down at one point at least the barrier erected by the mass-production system of education between professor and student, as well as the barrier between youth and maturity.

12. The students feel strongly that the conferences should begin earlier than the senior year.

Next semester there will be guest leaders of the discussions—eminent men in politics, science, labor, and management of industry, thus bridging the gap between campus and community, between books and life as Sir Walter Moberly does at St. Catherine's. We call them "professional-development conferences" because they bring both science and the humanities into a professional focus.

Industrial interviewers who come to hire seniors are already remarking that this group seems to show a maturity of outlook and judgment greater than usually found among seniors.

It cannot be claimed that such conferences infallibly will insure that all students will build a rational life view based

on justice and reason, but for our American educational system it at least makes that achievement possible. These conferences also stimulate self-education a much-needed step. Our present-day emphasis on specialization makes a step in this direction necessary.

Urgency of the Case

Belief in justice, reason, and truth are the only foundations for these philosophies. Once we of the western democracies suspect that justice and reason are the out-of-date ideologies of a bourgeois age, mere screens for selfish interests hiding behind them and, indeed, sources of confusion and weakness to anyone who would trust in them, democracy is through.

The communists teach that the only real forces in life are economic interests, power, and subconscious desire. Justice is nothing but the will of one section; and there can be nothing higher than the longing for materials benefits—so that to talk about higher missions is just foolishness or deceit. As Professor Polanyi [2] points out, a generation has grown up full of moral fire and yet despising reason and justice. Hatred and class war thus become the means of liberating men from the delusions of truth and compassion. The Russian youth disbelieves in public morality in the way we disbelieve in witchcraft. It is not that he has never heard of it, but that he thinks he has valid grounds to assert that such a thing cannot exist. If you tell him the contrary, he will think you peculiarly old-fashioned, or simply dishonest.

For educators the problem is simple: How can young men be aided in building a rational life view based on justice and truth? The professional-development conference is one method that works.

[2] "The Logic of Liberty" U. of Chicago Press 1951. M. Polanyi, F.R.S.

Sections and Branches

The **National Capital Area Section** held its Winter Meeting February 3, 1953 at the University of Maryland. President Woolrich introduced the members of the ASEE Executive Board which had met at the University that day. He discussed some of the problems for which the Board is striving for solutions, *e.g.,* the tendency of young engineers to join unions.

The meeting's subject was "How can employers get needed engineering work done in the face of long continuing short supply of engineers? How should engineering schools assist?" This was discussed: For government by Dr. Allen V. Astin, National Bureau of Standards; For industry by Mr. Donald S. Bridgeman, A. T. & T. Co.; For engineering education by Dean Martin A. Mason, George Washington University. Several means of attacking the problem were suggested by the speakers and in the lively discussion following: Use technicians for routine engineering work; Hire more technical institute graduates; Improve capability of technicians and engineers by in-service educational training using engineering schools to aid; Employ technicians and engineers for capability rather than education alone; Improve competency of supervisors; Improve management and administration.

Integration of Chemical Engineering Fundamentals

By J. M. SMITH

Professor of Chemical Engineering, Purdue University

Probably early in the career of every teacher of upper level courses in chemical engineering, an experience has occurred impressing him with the inability of the average student to make proper use of his earlier training. In undergraduate courses in thermodynamics, it is not unusual to find at least one student each semester that is unable to utilize enough of his training in calculus to integrate $C_p dT/T$ for entropy calculations. The usual answer given when the student is questioned about such lack of mathematical technique is "Oh we studied that in Math 4," implying that it was not quite sportsmanlike to expect him to bring to bear material from an earlier course upon current problems.

I should like to examine the thesis that the failure to integrate principles from separate courses is not entirely the fault of the student. Enginering education is continually associated with the process of analysis, particularly throughout the undergraduate curriculum. The student is taught to break down a complex problem into its component parts, the solution of each of which may be simple. This analytical approach is of great value and must be a foundation stone in the building of an engineering education. However, by implication it leaves the impression that there is not a real need to be able to integrate diverse principles and concepts in a successful attack on certain types of problems. Unfortunately, the mechanics of ending a course with a final examination and receiving a final grade may also suggest to the student that he too is finished with the subject material of the course and will have no further use for it.

A number of proposals for avoiding this pitfall in engineering education have been proposed in the past, and it is not the intent here to suggest a new or original solution. Instead the objective is a description of the measures that have been used in chemical engineering at Purdue.

Chemical engineering is a sufficiently narrow field that a thorough understanding of but a few basic principles is sufficient to make a satisfactory attack on most problems in the field. This fortunate state of affairs offers a means for integrating the various courses in the usual chemical engineering curriculum. This plan, stated simply, is to broaden the scope of the problems given in one or more of the senior courses so as to require the application of a number of the principles. In this way the student is obligated to recall and utilize previous and concurrent subject materials. Such training through work with repeated problems of this type prepares the embryo engineer admirably for his career in industry. The problems encountered there are likely to be so varied and complicated that unless he develops the habit of attacking them from the point of view of the fundamentals his chances for success are limited. If he is required to utilize this philosophy while still in the university, he is off to a head start, for it has become habitual for him to analyze a problem in terms of basic concepts.

Principles of Chemical Engineering

The five principles which the chemical engineer uses in his analysis of problems in unit operations and chemical processes have been recently well stated and discussed by Kirkbride (1). These may be expressed as 1), the conservation of mass, 2), the conservation of energy (first law of thermodynamics, 3), the laws of equilibrium (second law of thermodynamics), 4), principles of rate processes, including rate of mass transfer, energy transfer and chemical reaction, and 5), the principle of economic balance.

It is not important which courses in the chemical engineering curricula are used as the integrating ground. At Purdue unit processes and unit operations are given in the junior year so that the senior thermodynamics course is employed for this purpose. At the graduate level applied kinetics and reactor design serve as the integrating area, because they offer the oportunity of using nearly all the principles in comparatively short problems.

Applications

In order to illustrate the type of problems which have been used, two examples will be given from the undergraduate thermodynamics course. In the study of phase equilibrium it is desirable to refer to the use of phase equilibrium constants in evaluating the composition of multicomponent gas and liquid phases in equilibrium. Rather than offer examples involving dewpoint and bubble point calculations, the problem of determining the composition and extent of the gas and liquid phases in partial condensation or vaporization is presented to the class. In order to obtain a practical background the operation of a partial condenser in a distillation unit may be employed. In the solution the necessity of combining principles 1), in the form of a material balance for each component, and 3), as a phase equilibrium equation, is clearly brought out.

As a more complex case, the problem of determining the final composition, temperature, and pressure after a constant volume combustion is frequently given. The internal combustion engine can be used advantageously to give the problem practical support. Conditions are chosen such that combustion is not complete but equilibrium is reached quickly, so that the principles of chemical reaction equilibria are applicable. When the conditions for heat transfer to the cylinder jacket and the initial temperature, pressure, and fuel composition are specified the problem is fixed. The necessity of a trial and error solution quickly leads the student to the conclusion that he must combine (1), the principles of conservation of mass in order to express the stoichiometry of the reactions in terms of the minimum number of variables, (3), the principle of chemical reaction equilibrium in order to relate the equilibrium composition, and (2), an energy balance, and (4), a heat transfer expression in order to relate the temperature to the equilibrium composition. This example offers, in a short problem that can be worked out to a numerical solution in an hour or two, a means of illustrating the simultaneous application of the four technical principles in chemical engineering. The calculations are not particularly involved or tedious so that the student does not become occupied with numerical computations to the point of missing the fundamental concepts.

There are an unlimited number of examples as good or better than the two described. In a course in unit operations the design of heat exchangers for high gas flow rates can be used to show the necessity of combining a basic energy balance, which includes kinetic energy changes, as well as the usual heat transfer relationships. The subject of heat exchanger design serves admirably as a medium to bring out the application of the principle of the economic balance, along with rate and energy equations. The design of flow reactors in the general

case of non-adiabatic, non-isothermal operation provides a vehicle for illustrating all the fundamental principles. Mass balances are necessary in treating the stoichiometry of the reaction or reactions. Energy balances serve to relate the temperature to position in the reactor (and the pressure also, if the pressure drop through the reactor is significant). Equilibrium relationships will be required if the chemical reactions are reversible. Three forms of rate expressions are needed for the solution: rate of chemical reaction, rate of heat transfer radially, and rate of mass transfer radially in the reactor. Finally, the optimum design solution will depend upon the cost of raw materials, cost of equipment, and operating expense, and, therefore, requires an economic balance.

Plant Design Course as an Integrating Tool

In some respects the usual plant design course in the senior year serves to correlate the separate subjects in the chemical engineering curriculum. Perhaps the most common procedure is to assign the student section a complete design for one or two different plants. This approach can be of considerable value in accomplishing the objective proposed here, provided emphasis is given to bringing together the principles studied in separate, previous courses. For example, division of the class into small groups each of which is given one phase of the plant design would not be expected to accomplish the desired result. Despite the usefulness of the design course, it is believed that the opportunities for integrating the principles of chemical engineering that exist in the other courses should not be neglected. Thus in thermodynamics 20–30 problems may be assigned each semester. If half of these involve the simultaneous application of two or more of the basic principles, considerable progress has been made in developing in the student the habit of attacking problems from the viewpoint of the fundamentals.

Conclusion

One of the important advantages of the fundamental approach is the confidence it gives the student in his ability as an engineer. He enters upon his career in industry not with the fear of insufficient factual information to attack the new problems encountered, but with the confidence based upon successful experience in solving a wide variety of problems in the university by integrating the basic principles.

REFERENCE

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Reliability vs. Validity of Examinations

By IRWIN WLADAVER

Assistant Professor of Engineering Drawing, New York University

Reliability and validity are the most misunderstood—or the least understood—concepts in the construction and evaluation of objectively-scored examinations. Sometimes the terms are used interchangeably by professional writers and teachers who ought to know better. But here is one case in which precision does not permit interchangeability.

It is not necessarily true, however, that reliability and validity are mutually exclusive. In fact, proof of reliability can be used to support a claim for validity. But while reliability can be *proved,* validity cannot. This statement cannot be successfully disputed, for reliability is by definition a function of statistics whereas validity is a function of human judgment, fallible as we know it to be.

The reliability of a test is a measure of its consistency. For example, if a "reliable" test were given twice to the same students—or if a retest were made with an alternate, equivalent form of the original test—the scores would be practically identical on both occasions. But we know perfectly well that we often find it impossible or undesirable to give the same test twice to the same students (except in the cases of some unhappy individuals who must take the course twice). And so three or four fairly easy statistical techniques have been devised to give "estimates" of the reliability of test scores. Proof of reliability is considered to have been obtained if the statistical manipulation gives a sufficiently high coefficient.

But the reliability of a test does not take into consideration the content of the test; all it indicates is the degree of consistency of the scores obtained. Suppose, for example, we have a group of students who know only English (if that) and we have to test them in descriptive geometry. We give them the following five questions:

1. What is your name?
2. Come si chiama?
3. Comment vous appelez-vous?
4. Vie ruhft mahn dich?
5. Kak teebyeh zahvouch?

Practically every student can answer the first question correctly and will. Unless he guesses that we have tried the same question in Italian, French, Yiddish, and Russian, he will always answer the one question correctly and always fail on the others. The test is *perfectly* reliable, that is, consistent. But we are all willing to grant that it is not a particularly good test in descriptive geometry. To say it another way, the test is completely reliable; we can get statistical proof. But the test has no validity for descriptive geometry; our judgment tells us so.

The validity of a test is the degree of fidelity with which the test measures whatever it purports to measure. And this is a matter that is not at all completely amenable to statistical analysis.

It is true that some statistical evidence is desirable. For example, if a test has high reliability, we have some evidence in support of its possible validity. At least we can know that the test will report consistent scores. If the test is inconsistent in reporting scores, to that extent validity is impaired. But statistical analysis of a whole test and each item of the test can do no more than make some contribution to the validity of a test.

Points of View

In this brief article it is impossible to do much more than name some of the more important points of view from which validity can be investigated and claimed:

1. Statistical analysis.
2. The determination of validity through the use of certain groups, that is, through correlation with outside standards themselves known to be valid.
3. The extent to which the operations required of the student—by the test—appear to parallel the operations demanded by the course of study named in the title of the test.
4. The extent to which the subject matter content of the test is in agreement with the curriculum and good teaching practice.
5. The extent to which the test has been constructed according to sound practice.
6. The extent to which other teachers and experts agree to the soundness of the test.

Notice the part that human judgment plays throughout.

Reliability can be measured and a test can be said to be reliable to a specific degree, because the measurement has a mathematical basis. But validity of a test can never be 100 per cent established, since its basis rests on human judgment —even though it be relatively expert judgment, judgment like yours and mine.

Fifth College-Industry Conference Proceedings Available

Eleven papers from the 5th College-Industry Conference, sponsored by the Relations With Industry Division of ASEE at Northwestern University on January 31, 1953, are available in mimeographed form. These can be ordered from the Secretary, ASEE Office, Northwestern University, Evanston, Ill. The price is 50¢ per copy. Please enclose a remittance with your order.

TIMELY TIPS

Curves of Distortion

By ARTHUR M. HILL

Professor and Head of Mechanical Engineering, Tulane University

Volumes have been written on "good teaching techniques" and more will come in future years. But one academic practice which might be dusted off and re-evaluated is that of "grading on a curve."

The teacher who is a "curve enthusiast" will probably fall into one or more of these classifications: (a) teachers who feel that a grade of A in a subject indicates a "crip" course; (b) teachers who are not able to adjust quizzes to the background of class work and student ability; (c) those who insist upon forcing each year's class into a set mold, convinced that each year there must be a fixed percentage making A, B, etc., regardless of the variation in student material; and (d) those who feel themselves in a position of power due to the awe and mystery with which they surround their grading system.

Part (b), "teachers who are not able to adjust quizzes to the background of class work and student ability," might be discussed further. Upon reflection, most any instructor should realize that the average student thinks of the dividing line between passing and failing as a grade of about 70%. It is a poor personnel relations job for an instructor to pride himself on a class average of 45%, and then prop up these grades to the passing level by curves. Why not give realistic quizzes which result in realistic grades in the first place?

Industrial firms spend many thousands of dollars in carefully defining the working conditions of their new employees. Why would it not be beneficial to start the first class meeting in a course with a concise discussion of the grading system? If the average of the quizzes in the course will count for two-fifths, why not tell the student so? Definite numerical brackets as to where grades of A, B, and C fall would be helpful. If *you* were the student, wouldn't *you* like to know?

In a short time, many of these students will be on training programs in large industrial plants. In most cases their achievements and progress are carefully recorded and graded. I have never known of a supervisor of these young engineers who had to resort to a curve to evaluate their performance.

Life is sufficiently complicated for students and faculty at best. Why not simplify things and discard the curves of distortion?

February 13, 1953

A Single Tube Square Wave Generator

By O. WILLIAM MUCKENHIRN

Associate Professor of Electrical Engineering, University of Minnesota

The ever increasing applications and associated analyses of square waves in electrical engineering has made it desirable if not necessary to introduce the student to this material in the early stages of his undergraduate curriculum. In the classroom this presents no problem but in the laboratory, experimentation by a large

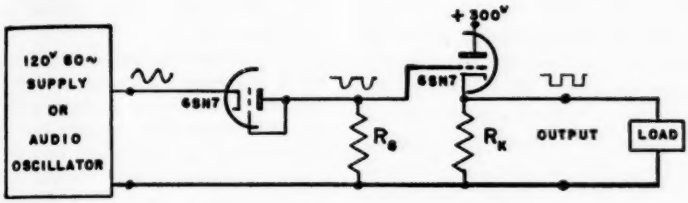

FIG. 1.

number of student groups becomes prohibitive because of the high cost of commercial pulse generators. For the study of square waves, differentiating and integrating circuits, etc., in the basic electronics course at the University of Minnesota a simple single vacuum tube square wave generator with a low internal impedance is used.

The circuit diagram of the generator is shown in Fig. 1. One of the triode sections of the 6SN7 operates as a half-wave rectifier while the other section operates as an overdriven cathode follower. In this way the cathode follower performs the function of clipping as well as preserving its inherent low internal impedance characteristic which facilitates loading. One feature of the unit is that the top and bottom portions of the square wave output are perfectly straight. This results from the fact that during the overdriven period (when the rectifier section is passing current) there is no current through R_k and therefore zero output voltage and when the rectifier section does not conduct the cathode follower operates under static conditions with a direct current through R_k which in turn provides a constant output voltage. The rise time is satisfactory for most purposes and may be adjusted by varying the amplitude of the driving unit. The magnitude of the output voltage may be adjusted by varying either R_k or the plate supply voltage of the cathode follower. Generally, an increase in output voltage is obtained at the expense of increased rise time.

As presently used, the generator is driven from a 120 volt 60 cps system through a 1:1 isolating transformer and maintains an output voltage of approximately 15 volts with $R_k = 2000$ ohms and $R_G = 10{,}000$ ohms. For other repetition rates an audio oscillator driver could be used. It is assumed that plate and filament supplies and proper driving facilities would be available where this unit would find application.

The quality of the output wave form is shown by the oscillograms of Fig. 2. The first oscillogram shows the output voltage

FIG. 2.

while the second shows the voltage output of a simple integrating circuit driven by the square wave generator. The integrating circuit consisted of a 50,000 ohm resistor in series with a 2-microfarad condenser. These oscillograms were photographed on a Dumont model 304H Oscilloscope. Deviations from these wave forms are likely to be observed on cathode ray oscilloscopes with limited response characteristics.

It is felt that this square wave generator which is connected by the student groups not only contributes to their understanding of vacuum tube circuits but also enhances their knowledge of non-sinusoidal circuit phenomena and should be of interest to other educators working in this field.

Just Out . . . .

Manual of Graduate Study in Engineering

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SUMMARY OF ASEE

Manual of Graduate Study in Engineering

Committee on Revision
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Introduction

The original Manual of Graduate Study in Engineering was prepared by the Committee on Graduate Study of the Society for the Promotion of Engineering Education and was published in the Journal of Engineering Education in June, 1945. Instead of summarizing the background of that work we will reproduce in full the Foreword from the first edition.

By 1950, it had become clear that certain concepts of 1945 had already been changed by the impact of post-war conditions. Accordingly, in 1950, President Thorndike Saville of the American Society for Engineering Education appointed the Committee on Revision listed above. This committee found the basic concepts of the Manual to be in all respects sound and useful. Certain practices were found to have changed; for example, the gradual acceptance since 1945 of the belief that one foreign language used purposefully in the doctoral program could be more helpful than a limited ability to translate two foreign languages. Also, much experience has been gained since 1945 in the association of graduate students with sponsored research, with cooperative educational programs and with evening and extension courses. Contacts have also been extended with the problems of foreign students. To account for these changes it was found necessary to revise about one-third of the Manual but in no instance did the committee on revision find it necessary or desirable to change major conclusions or recommendations of the original document. It is felt therefore that the Manual on Graduate Study in Engineering has served a most useful purpose in guiding the growth of our graduate schools of engineering and that it will continue to serve such a purpose in the future.

The following is a summary of the Manual. Copies of the complete manual can be obtained by writing to the Secretary, Professor A. B. Bronwell, Northwestern University. Price 50¢ per copy.

Summary of Conclusions and Recommendations Regarding Graduate Study in Engineering

1. Objectives

If oversimplification is permitted, the objectives of graduate study can be stated as the development of men able to experiment or otherwise to collect, appraise, digest and analyze evidence, and trained to prepare a clear statement of the findings. Such studies should advance intellectual honesty, imagination and courage.

2. Organization

Graduate and undergraduate instruction benefit by close contact for they are

complementary functions that may be performed effectively by the same teacher, but they are sufficiently distinct in their objectives to be differentiated through certain phases of administration such as faculty designation, and budgetary control.

3. Transitional Studies

To encourage undergraduate students of unusual scientific abilities toward greater intellectual effort it is recommended that they be given more freedom in the choice of courses including such graduate courses as their development *fully* justifies and that arrangements for their first association with research and research professors be made as a part of their undergraduate programs.

4. Developing a Graduate Faculty

The development of a graduate faculty requires administrative encouragement of professional objectives, of research and scholarship as evidenced by a sympathetic understanding of the scholar's problems, appreciation of his accomplishments, financial support for his work and an adequate personal reward.

5. Admission Requirements

Fuller realization is needed that only students who rank in the upper quarter of the graduating class are likely to become strong candidates for an advanced degree. Devices such as trial registration, entrance examinations, preliminary examinations for the doctorate and others may be used to uphold the proper standards of the graduate school.

6. Degree Requirements

Formal requirements for advanced degrees in engineering are properly set by each institution although there is general agreement upon one academic year of residence study for the master's degree and three years for the doctorate. More detailed formal requirements will be needed to guide the average student, but it should not be forgotten that the graduate school remains the province of the superior mind.

7. Major, Minor and Research

The "major" should be devoted to one field of study and should include the thesis research, but departmental lines should not be restrictive in the selection of courses or teachers. One "minor" (for the doctorate) is recommended in a field of science or engineering clearly separated but contributing to the strength of the major study. The length of the doctorate residence makes two minors permissible.

8. The Thesis

A thesis is recommended for all advanced degrees in engineering. For the master's degree, it is considered to represent training in research or in the more scientific phases of design or development. For the doctorate, the thesis is considered as evidence that a candidate has made a contribution to science or to engineering knowledge.

9. Language Requirements

As an alternative to the usual required "reading knowledge of French and German" for the doctorate, it is recommended that evidence be accepted that the student has command of one foreign language which he has used effectively and extentensively in relation to his thesis.

10. Mathematics

Graduate study in engineering emphasizes the mathematical or scientific approach to the solution of technical problems. It is accordingly recommended that the master's program should be strengthened by requiring one or more courses in mathematics beyond a first course in differential equations, and that the doctorate should commonly include a minor study in advanced mathematics.

11. Examinations

Greater emphasis should be placed upon comprehensive examinations of the combined written and oral type for both master's and doctor's degrees. These serve not only as a yardstick to measure the attainment of the student, but also as a

rather tangible expression of the objectives of graduate study and as a means of bringing them to the attention of students and faculty.

12. Undergraduate Courses

Undergraduate course work should be accepted for graduate credit only when taken in fields for which the student is not expected to have the prerequisites for full graduate study and then only when taken as an approved part of a graduate study program. Also, it is recommended that no more than twenty-five or thirty per cent of the program be permitted in undergraduate courses and then only in the first full year of graduate study.

13. Non-technical Studies

The recommendations in 12 above are also to be applied to graduate studies in economics, political science and administration which may be proper related optional studies for certain fields of engineering.

14. Evening Classes

Evening graduate study is accepted to be of the same significance as graduate study in the day. Its cooperative features for maintaining close association with industry are recognized to be of importance.

15. Cooperative Programs

Cooperative graduate study does not necessarily involve alteration between industry and education but might be based upon a leave of absence from industry with the thesis research in some way related to a company interest. Many other cooperative arrangements exist through institutional extension courses at industrial locations. Cooperative arrangements have been increasing and may be expected to become a very important factor in engineering graduate study.

16. Sponsored Research

Sponsored research of a clearly fundamental nature in residence has the same educational value as institutionally sponsored research and is the only kind of sponsored research acceptable for the doctorate thesis. The percentage of the students' time given to basic research should be determined objectively for assigning residence credit since much work on a research project is necessarily of a routine nature. For the master's degree greater freedom is suggested and some graduate credit is acceptable for industrially sponsored development work when placed under qualified educational supervision.

17. Industry Institutes

Graduate institutes serving a single industry face the problem of domination by that industry which may result in the use of vocational standards for measuring graduate-study objectives. This will be combatted most effectively when such institutes are closely associated with colleges or universities which foster other graduate study in science and engineering.

18. Foreign Students

A semester of orientation into American graduate study is recommended for the foreign student who often needs supporting work in English, in laboratory science, or in practical engineering courses. These are common deficiencies.

19. Student Guidance

The most practical advice to brilliant undergraduates is to enter the graduate school immediately after graduation before there is a loss of facility in the use of mathematics, physics, and the theoretical tools of engineering. Graduate students should be treated as adults, but they still need guidance in the importance of using the library and of setting up, stating, and solving problems.

20. Teaching Loads

It is recommended that teaching loads be based upon an analysis of total instructional hours including class hours, preparation, grading, and counseling for both graduate and undergraduate courses. Evaluation of the equivalent teaching load involved in direction of thesis research should be made.

TEACHING POSITIONS AVAILABLE

The following rules were adopted by the General Council of the ASEE:

1. The privilege of advertising for teaching positions is extended only to colleges and technical institutes which are either Active or Affiliate Institutional Members of the ASEE.

2. Advertisements must be for positions available only. No advertisements will be accepted for an individual seeking a job.

3. Advertisements should not specify salaries.

4. Advertisements must be submitted not later than the first day of the month preceding the month of issue.

5. Because of limited staff, the ASEE headquarters cannot maintain personnel files or supply detailed information about jobs. In replying to blind ads, address letters to American Society for Engineering Education, Northwestern University, Evanston, Illinois and give blind ad number.

6. Information and rates for advertising in the Journal can be received by writing ASEE Headquarters.

7. In order to conserve space and achieve uniformity, the privilege is reserved to rearrange advertisements.

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Section	*Location of Meeting*	*Dates*	*Chairman of Section*
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Illinois-Indiana	Rose Polytechnic Institute	May, 16, 1953	H. A. Moench, Rose Polytechnic Institute
*Kansas-Nebraska	Kansas State College		M. H. Barnard, University of Nebraska
Michigan	Detroit Institute of Technology	May 9, 1953	C. C. Winn, Detroit Institute of Technology
Middle Atlantic	University of Delaware	May 2, 1953	C. Bonilla, Columbia University
Missouri	Washington University	April 11, 1953	G. F. Branigan, University of Arkansas
National Capital Area	Howard University	May 9, 1953	L. K. Downing, Howard University
New England	University of Vermont	Oct. 10, 1953	E. T. Donovan, University of New Hampshire
North Midwest	Marquette University	Oct. 9–10, 1953	A. B. Drought, Marquette University
Ohio	University of Cincinnati	May 2, 1953	H. K. Justice, University of Cincinnati
Pacific Northwest	Washington State College	April 24–25, 1953	J. P. Spielman, Washington State College
Pacific Southwest	San Jose State College	Dec. 29–30, 1953	C. M. Duke, University of California at Los Angeles
Rocky Mountain	University of Colorado	April 11, 1953	C. A. Hutchinson, University of Colorado
*Southeastern	North Carolina State College		D. V. Terrell, University of Kentucky
Southwestern	University of New Mexico	April 3 & 4, 1953	M. L. Ray, University of Houston
Upper New York	Rochester Institute of Technology	October, 1953	F. E. Almstead, State University of New York

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576 new members elected this year

Emotional Response to Teaching Techniques*

By N. A. CHRISTENSEN

Director, School of Civil Engineering, Cornell University

The emotional reactions of a student toward his teacher play a most profound part in his learning process. If his emotional reactions are correct, almost any technique will work and if those emotions are wrong, no technique will give results.

To more clearly illustrate my meaning, I wish to recall a painful personal experience, from my childhood days, as an elementary grade school student. In my town of 12,000 people, there were four grade schools and one music teacher. Each week he visted each school in order to teach the students to read music and sing simple songs. He taught classes in the fourth, fifth, and sixth grades so my first exposure to his teaching was as a fourth grade student.

Te begin with, music moved along much the same as other subjects in a satisfactory way but with no special interest attached to it. Then came a day when we were asked to write a few stanzas of music, and for some reason, I tried to make mine look like a printed sheet. When finished, it looked neat and a mild feeling of pride was mine as I handed it to the student in the front on its way up to the teacher who was standing at the front of my row. His habit was to glance briefly at the papers as soon as he got them and so I was watching him to learn his reaction. One, two three; mine was the fourth down from the top of the pile. When he came to it, he paused a little longer than usual, smiled and handed the paper to our regular room teacher saying, "It looks like a printed sheet." This was exactly what I had been trying for and his offhand remark, unknown to him, had a profound effect upon my efforts in music for the next year. My interests in the music teacher as well as in music sharpened. For the first time I noted that this man could sing all four parts of almost any song. Gee, what a *singing range* this man had! I learned he was also the conductor of the church choir and admired his masterly control of over 100 singers whom he trained. In my mind his greatness as a musician was finally and solidly confirmed when he led the congregational songs. You could hear his voice above all who sang even though the number of singers sometimes exceeded one thousand. Boy, what *volume* that man had!

With this state of mind and emotions, his classes became a pleasure for me. When he would say sing, I would do so with all my might and I knew I was making real progress. My confidence grew and I took the responsibility to sing out so that my seat neighbors followed my lead when we sang.

By this time, I had a slight touch of swelled head, an ailment so common among fourth graders of which, of course, I knew nothing. It was true the other students were following my lead in singing. This exaggerated my ego and in my own mind I was going to march right along and be like the teacher himself, until one day I made a sad mistake. We were reading music in the do, re, mi fashion, and came to a long run of notes forming an ascending scale which ended in the top space of the staff at a note called re. To my sorrow, in climbing this musical scale,

* Presented at Upper New York Section Meeting of ASEE, Oct. 11, 1952.

my reading got out of gear with my singing and lagged it by one note so for me there was still one more note, mi, to sing when the class had reached the top and I hit that mi with all my might. Because of egotism and false confidence, I held it for its full count.

My budding music career as well as my ego collapsed with the burst of laughter and ridicule from the class. A blush of shame burned my face and made me look even more ridiculous to all present. My idol, the music teacher, completely misunderstood my error and interpreted it as a show off. My cup of grief overflowed when he proceeded to soundly box my ears.

My hero, the music teacher, suddenly became a crude baboon with heavy powerful hands. It seemed to me that he had a tendency to show off for the benefit of the pretty homeroom teacher. His range was not so marvelous after all, only two octaves. Any good baritone should have two and a half. His strut before his choir now annoyed me. What a horrible mess he made of congregational songs, his voice rose above the singing of the congregation like a bellowing bull. What a fool I had been not to see his true color before, but now I knew, especially since my pretty cousin had told me that he had tried to put his arm around her. He is just a grandstander for those females who are silly to fall for him.

Three years later I suffered no pangs of sympathy when the newspaper reported him laid up in bed with painful arthritis. It was eight years before I reluctantly consented to join his choir but by this time my ability to read music was still embryonic and so the best I could do was to follow my older brother who had had a more happy experience under this master of music.

Looking back now, the true nature of the experience is clear. The slap I got did not change the teacher, his technique did not change, his personal qualities did not change, it just seemed that way to me. The slap changed my whole frame of reference for judging him and his techniques. Before the slap he was wonderful and I was a dilligent student making good progress. After the slap he was the lowest of humans. I was balked and my progress in music stagnated. Any technique which improves the emotional relations between student and teacher is good. My teacher's observation that my written music was neat, was good technique; his slap was bad technique. The commendation conditioned me emotionally to learn; the slap raised enormous emotional barriers.

These emotional adjustments are not static. They improve or decline. One very important factor affecting this rise and fall is the progress which the student makes. The changes are usually much more gradual than mine, when I got slapped, but nevertheless each action of the teacher has its effect upon the student-teacher relation. An alert experienced teacher will sense these changes and adjust his techniques in accordance. The sum total effect of a teacher's techniques, build or destroy the students emotional adjustment to him.

Guiding Principles

There is enough uniformity of response of students to permit the statement of a few general guiding principles.

1. Watch the students and judge your techniques in terms of the reactions and activities stimulated in the student. They learn only by their own mental activity. You can't pour knowledge into them.

2. Master the subject matter. A complete knowledge of one's subject is necessary, especially in basic undergraduate courses. Without complete command of the subject matter, the teacher will not have time to study the reactions of his students in the relatively large undergraduate classes. The highest form of student respect is not possible if the teacher is not master of the material he is teaching.

3. Use a variety of approaches to the subject matter. In the *Journal of ASEE* last May, Mr. Harry W. Case, Associate Professor of Engineering and Psychology of the University of California, in report-

ing the results of his questionnaire to students on teaching techniques, emphasized the importance of this item and the danger of monotonous teaching.

4. Attack the job of teaching with enthusiasm and vigor. Whatever techniques are selected use them with gusto. Students become alert in the presence of such a teacher. This vigor should have a natural quality such as grows out of a feeling of having something good one wants to transmit.

5. Put the students at ease. Students should feel free to state their own ideas, without fear of ridicule. Admit your own errors freely and students will then do likewise. Crack a joke on yourself once in a while, a sense of humor will ease tensions and make the teacher seem more human to the students. Care on this point is necessary, however, in order not to impair respect for the teacher and class order.

6. Strive for an atmosphere of ease dignity of the type which grows out of living up to our professional codes of ethics. A commendation of a fellow teacher before a class, in a subtle but powerful way, adds stature to the teacher giving the praise, providing it is sincere. Cheap jokes should be avoided like the plague. They are distructive of dignity and, worst of all, their telling is highly contagious.

I am afraid that these six points may seem like platitudes. The ideas are common but they do not qualify as platitudes, because they are not given as new or profound. They are as common as an old shoe but nevertheless of basic importance.

One cannot be much more specific in recommending teaching techniques because if he does, he faces the danger of reducing the teaching process to a mechanical routine. Administrators of education, I believe, should not insist on teachers adherence to a specific set of techniques because by doing so, they may lose the value tied up in each teacher's own personality. His adjustment to his students will be made best if he is free to sort the techniques to fit his own classes and himself. All teaching techniques can be rightly considered as only means to an end. That end being to establish emotional relations between teacher and student most ideal for the transmission of knowledge.

College Notes

The potentialities of modern electronic processing systems will be emphasized during a two-week Special Summer Program on Digital Computers and Their Applications from August 24 to September 4 at the **Massachusetts Institute of Technology.** The program is especially designed, according to Dr. Ernest H. Huntress, Director of the M.I.T. Summer Session, for those unfamiliar with digital computers who must determine how newly-available computing systems can be applied to their problems and the advantages that might accrue. No previous training or experience beyond a bachelor's degree in business, science, or engineering will be required. The program will be under the direction of Charles W. Adams, Assistant Professor of Digital Computation in the Department of Electrical Engineering. He will be assisted by other members of the staff of the M.I.T. Digital Computer Laboratory, who will act as occasional lecturers and as instructors for small working groups.

Curriculum and Cocurriculum*

By C. MARTIN DUKE

Associate Professor of Engineering, University of California, Los Angeles

This paper developed from an effort to think out the place in engineering education of the non-academic activities given much emphasis in most American engineering colleges. A certain pattern has been found in the methodology and objectives of these activities, and the name cocurriculum has been adopted for them. The pattern is presented here in the hope that it may stimulate discussion leading to clarification of the role of engineering cocurricula..

The objectives of engineering education may be stated to be the development in graduates of intellectual capacity and professional attitude. These are attained through the devices of curricula, or groups of courses, and cocurricula, or groups of activities. A diagram of engineering education is presented in the chart of Figure 1 to show the functions of curriculum and cocurriculum. The definition of the latter term proposed by the writer follows:

> The cocurriculum of an engineering college consists of those activities paralleling the curriculum which are carried out by students, faculty, and practicing engineers with the objective of developing a professional attitude in students toward their education and in graduates toward engineering work.

The activities mentioned are here classified as student activities, personal functions of faculty and professional engineers, guidance, inspiration, recognition of and aids to achievement, and contact with engineering practice. The professional attitude given as the objective of these activities is a complex of several states of mind or attitudes which are herein classified as morale, orientation, purpose, motivation, and preprofessional engineering experience. These five states of mind characterize the professional attitude required in graduates and also that required in students toward their education. The quality of the result achieved by the cocurriculum depends firstly on the moral caliber of the students and secondly on the excellence of cocurricular planning and execution.

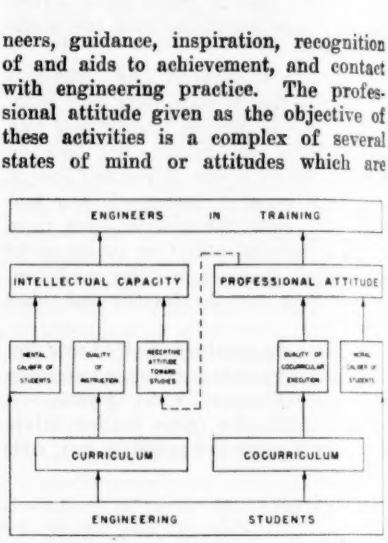

FIG. 1. A diagram of engineering education

The intellectual development required in engineering graduates is the concern of the curriculum. It is the principal objective of the academic portion of the student's collegiate experience and is concerned with the capacities of analytical

* Based on a paper presented at the annual meeting of the Pacific Southwest Section, American Society for Engineering Education, December 27, 1951, Reno, Nevada.

power, creative thinking, skill with the engineering method, knowledge of engineering subject matter, and understanding of society. The result achieved depends on the intellectual caliber of the students, on the state of mind of the students toward their studies, and on the planning and quality of instruction.

Curriculum and cocurriculum do not exist as separate entities (though usually they are operated separately in engineering schools). For example, purpose may be stimulated as well in the classroom as through contact with practice, and technical and humanic knowledge is abetted by field trips and student organization experience. Further, as illustrated by the dotted line in Figure 1, the cocurricular activities should do much toward developing a receptive attitude toward the academic work.

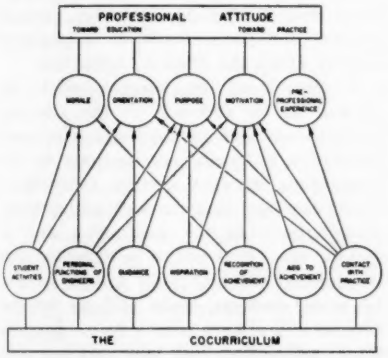

FIG. 2. The cocurriculum

Figure 1 illustrates how the engineering educational process, working through the curricular and cocurricular stems, may produce high caliber engineers in training. In Figure 2 the activities and attitudes given above are charted, and predominant cause-and-effect relationships are shown by arrows. As in most block diagrams, oversimplifications exist in both figures: mental and moral calibers of students are not static things but fluctuate with development of attitudes; forces outside those considered, such as family and personal experiences, often predominate; feedback plays a major role in planning activities to develop attitudes. The following two sections define and describe the elements of the cocurriculum shown in Figure 2.

Activities of Students, Faculty, and Practicing Engineers

Most quickly recognized of the cocurricular activities is the group conducted by the students through their organizations and publications and labeled *student activities*. They have great morale value on account of the informal personal associations among students and between students, faculty, and practitioners. Services to the college and operation of an honor system help set the stage for accepting professional responsibilities to society. Working closely and voluntarily with other students helps to prepare graduates for the cooperative nature of engineering.

Seldom deliberately exploited by faculty and practicing engineers is their influence on student morale, purpose, and motivation by virtue of their personal example, reputation, fellowship, and advice. These *personal functions* are accomplished for better or for worse through intimate associations with students and groups in the classroom and office, in student organization affairs, and in preprofessional employment. Integration of the curriculum with the cocurriculum is achievable only through the cooperation of the faculty.

Particularly important in the precollege and early college years is *guidance*, including counseling, directed toward orienting and stimulating purpose in the students. In addition to the academic and career counseling and guidance given considerable attention in modern engineering schools, guidance should be provided in connection with features of the cocurriculum such as student activities and postgraduate professional activities.

An item of recognized primary importance, but difficult of definition, is *inspiration*. Certain inspirational activities car-

ried out by faculty, the profession, and industry, through programs and personal associations, are designed to stimulate imagination and emotional drives and thus to achieve motivation and purpose. Least tangible element of the cocurriculum, inspirational functions usually are accomplished only incidentally to other activities. A few professors and deans do make conscious effort in this direction, often with modest success.

Colleges and student organizations provide for the *recognition* of both curricular and cocurricular *achievement* through the media of degrees, honors, honor societies, student society officerships, etc. Prizes and honors also are conferred by the profession and by industry. Such recognition stimulates morale and motivation.

Aids to achievement are similarly provided as stimuli to morale and motivation. This group of activities includes such items as tutoring by honor students, study facilities, scholarships, loans, and facilities for student organizations.

Every engineering student's collegiate experience includes some *contact with engineering practice.* Practicing engineers and the employers of engineers perform a guidance and inspiration function here in creating the mental states designated as orientation, purpose, and motivation. In addition there is provided training and experience implementing the objectives of the curriculum. Students come in contact with practice during cooperative work study programs, on field trips, and by attending meetings of professional engineering organizations. The impact of this type of cocurricular activity can be very great.

Attitudes Developed through the Cocurriculum

As an ingredient of the professional attitude toward his studies, the student firstly should be enthusiastic about his engineering education and further should conduct himself in an honorable manner in his relations with faculty and fellow students; such a state of mind, existing in students individually and collectively, is called *morale.* Its symptoms are confidence, loyalty, honor, pride, enthusiasm, and good fellowship. It is stimulated by extracurricular student affairs and by proper attitudes of faculty, administration, and professional engineers. This morale should transfer to his professional life after graduation with the added items of loyalty and pride in the profession and in his alma mater.

The student should understand and should possess some perspective regarding the organization and workings of his college and of the engineering profession; this is *orientation.* Implied is the understanding of and willingness to accept academic and professional responsibilities. The orientation picture should comprehend the possibilities of shifting to peripheral curricula while in college or to peripheral jobs after graduation. Guidance and counseling activities, special courses, and preprofessional employment help to effect the desired orientation.

Purpose is an ideal approached by the student as he proceeds in the selecting of academic and professional life goals. Examples of goals are options in the curriculum, student society officerships, first jobs, long range career achievement, contributions to the profession and to society, etc. It is not to be expected that concise and constant goals will be selected by most students while still in college. Chance will always play a role. Inspirational association with men and projects, and contacts with engineering practice, render much aid in the selecting of engineering goals.

Students should be possessed of the emotional driving force enabling them to make progress toward the goals selected in the oriented picture; this is *motivation.* Classroom activities, inspirational experiences, recognition of and aids to achievement, and contact with practice all influence motivation as do many non-collegiate factors. Without motivation the student cannot achieve success either in college or in practice—a fact that teachers and advisers must have always in mind.

An introductory knowledge of some of the arts and skills of engineering should be obtained by the student before graduation to give him *preprofessional experience.* This item, while not classifiable as an attitude, nevertheless represents in addition to intellectual growth a certain maturity of mind which is a desirable cocurricular result.

Applications

Present use may be made of the presentation herein as an aid to seeking solutions to problems such as the following:

1. Emphasis to be placed on both the activities and the attitudes of the cocurriculum during each of the four college years and prior to college; related questions of what should be the philosophy of the cocurriculum in the first two years including junior college, in the second two years, in graduate school, in technical institutes.

2. Devising methods of measuring the effectiveness of cocurricula and their various elements.

3. Planning of activities to encourage a particular student reaction or attitude, such as orientation, morale, motivation, etc.; possibility of devising and evaluating inspirational programs in and before college.

4. Optimum proportions of student and faculty time to be devoted to the cocurriculum.

5. Emphasizing to the faculty and to the profession the key roles they play in the cocurriculum.

6. Decreasing the mortality of engineering students; related problem of easing the impact of failure on individual students while maintaining in the student body a philosophy of success.

The writer's thinking in connection with this paper and with the above list of problems has been aided by use of a large chart showing greater detail than it has been practicable to present herein. A limited number of copies of this chart is available to interested persons.

Summary

It is maintained that cocurricula are operated in engineering schools in order to encourage in students a professional attitude toward their education and toward engineering practice. This attitude is characterized by states of mind identified as morale, orientation, purpose, motivation, and preprofessional experience. The cocurricular activities carried out by students, faculty, and profession are all identifiable with one or more such states of mind.

It is hoped that by this presentation the thoughts of engineering educators will be stimulated toward further contemplation of the objectives and toward more effective planning and execution of the activities of the cocurriculum. If cocurricular experiences and philosophies of educators are catalogued over the coming years, it may become feasible to design ideal cocurricula.

The Engineer as an Individual in Industry

By H. N. MULLER, JR.

Assistant to Vice President, Westinghouse Electric Corporation

My assigned title for this discussion is "The Engineer as an Individual in Industry." There is just one key word in that title—"Individual." All of my remarks will concern the individual; the freedom of the individual, the dignity of the individual, the development of the individual, the retention of individual thought and action in a team atmosphere, and most important, the necessity for all these ingredients in maintaining our industrial strength—the keystone of a strong America.

Our industrial strength is inseparably coupled to the individual. I firmly believe that our vast productivity could never have been accomplished, on a *continuing* basis, under any character of economy other than our free enterprise system of American industry. We have produced so abundantly because in America we have had individual liberty; freedom for the individual to pursue his own ambitions, to save and to risk, to gain and be responsible for his own decisions and actions, good or bad, win or lose.

If this dignity and freedom of the individual is ever lost in America, our strength will inevitably decline with it. Our philosophy of life is the key reason for our strength. We have great natural resources, but there are nations with greater raw resources. Americans can certainly be no more intelligent than the people in the lands from which Americans came. We don't work harder, or even as hard in terms of expenditure of human energy, as the people of many lands. You may say that our great educational system makes the difference and is responsible for our strength. But this educational system is just one product of our basic concepts of individual freedom and individual opportunity.

We have been able to build the America of today only because all of our people are free to *think* and *act* as individuals, *each* to express in his *own* way his *creative, productive,* and *cooperative talents* that collectively result in national wealth, strength, and high standards of living. These fundamentals apply to men of all skills and educational levels, from common laborer to professional practitioner. And among the professions, the engineers have emerged as the group most critically important to the continued strength and future growth of our industrial backbone.

The Place of the Engineer

Let us analyze briefly the position the engineer occupies in industry. He has grown to be our key man. His influence predominates in almost all functions of a modern industrial organization. An increasing number of the other skills and specializations are dependent upon the creativeness, the productive genius, the analysis and the application of the engineer before their functions have usable significance.

More than any other group, it is the engineer who has created the vastly complicated maze of modern industrial society. With every additional technical innovation, the degree of complication increases, and an engineering background becomes a requisite for more and more of the key jobs.

This necessity for technological understanding applies to the productive organization and to all levels of management, as well as to the directly technical pursuits

in the departments of engineering. It is interesting to observe that over one-third of the top management people in America's largest producing corporations are graduate engineers. This percentage will continue to increase in the future for it is an inherent necessity.

Now let us relate this crucial station of the engineer to his thoughts and actions as an individual. In recent years forces have been at work in our country that would reduce the status of individuality. Our people are constantly lured by all kinds of schemes for collective security, by all kinds of "isms" and devices designed against some of our most basic ideals. The worst of this is that it is being done in the name of "liberalism" and "progressiveness." Each "liberal innovation," so called, with a professional do-gooder as its advocate, sounds like a real bargain. All put together, they simply mean that individual initiative is replaced by government paternalism, that self-confidence is replaced by collective reliance, and in the end, that dependence replaces independence. At that stage, security through government has replaced freedom, whether economic, political, or eventually religious freedom. It is an insidious, creeping kind of paralysis. It provides its own anesthesia until it is very late and hard to arrest. We have traveled down this road regrettably far already, but the engineers, through their unique post in industry, are the one group who can do more than any other in showing to a free people their self-created peril. This requires action, not just words, and it must come from the grass roots level by all engineers in industry.

Specifically, look at this problem of security as it relates to engineers in industry. Certainly the urge for security has always been in the breasts of men, and properly directed, it is a driving force responsible for much of our material progress. But this is only true as long as we define security as individual security. There is no basic driving force in collective security; indeed, individual action, achievement, risk and gain, are strangled by collective security. This must be made unmistakably clear.

In recent years industry has been met with all kinds of demands for greater security. These demands include sickness benefits, hospitalization plans, bigger and better retirement guarantees, an annual wage, absolute seniority almost regardless of ability, and numerous other forms of collective action. Some of these demands are decidedly good movements and they are entirely justified, but others are not. In few cases have the demands been related to individual achievement, and I have never seen the proponents of these plans point out that all payments inevitably must come out of production; hence, from the consumer.

Engineers can achieve real and enduring security as can all professional people who are both competent and ethical. Such security is founded on the dignity and freedom of the individual, never on collective security, and it has been achieved by thousands. It is based on the individual's real value to the community, the industrial economy, and the national welfare through his reputation earned by constructive service.

To be frank in a point-blank manner, any collectivism, including our common concept of unionization, is incompatible with truly professional performance. Collective action, however highly conceived, will eventually result in a leveling process, and will inherently result in a strong influence toward mediocrity for the individual. At that point, the professional man loses some of this ingredient of individuality. The freedom that creates a vigorous professional attitude has begun to wither, and if the process continues indefinitely, it may die.

All of the engineering students and young engineers in industry must be instilled with an appreciation of their responsibility to the profession as individuals. They should carry this inspiration through the span of their professional service if they are to fulfill their obligations and realize their opportunities in America.

In short, if security is based upon earned reputation resulting from active pursuit of opportunity, the achievement of that security is worthwhile, it has contributed to the development of the individual, and it has advanced our profession. Grasping opportunity and realizing the fruits of accomplishment is real security; any other securty cannot be enduring.

The Employer's Responsibility

We have observed that a great majority of the young engineers initially entering industry have the motivation toward individual accomplishment so necessary to professional growth and a maximum rate of progress. This fact is a real tribute to the job our engineering colleges do in the more abstract elements of a professional engineering education. There are exceptions, of course, but most are really healthy minded youngsters, looking forward to opportunity in American industry. What, then, are the responsibilities of the industrial employer in seeing that this inspiration is nurtured and that the young graduate's ideals are realized?

First, industry owes the young engineer the opportunity to know his organization and to find the right job in it. It is industry's obligation to provide high-level, flexible orientation and training.

A good program of training has so many benefits. The transition from directed-development in college to self-development in industry is no longer an easy one. While the craftsman of former years grew up with the business, the college graduate of today steps into a strange organization at a relatively high level. He has had no opportunity to understand, through long association, the methods and operation of the concern. During his first few years with the company, the young engineer is finding his place in the organization, attempting to understand himself, and shaping his professional goal. Frequently, he is establishing his family and generally his salary is modest. Closing the gap between his experiences on the campus and the realities of earning a living in a complex situation is not an easy task. Obviously, he needs assistance in making the transition from directed-development to self-development, and his faith in himself, thus bolstered, maintains his individuality through a crucial period.

Many industrial employers have recognized this need and currently do a good job of orientation and training. Unfortunately, not all do. It is interesting to observe that there are valuable by-products that turn up as a result of a good training program. Some of these have a very broadening effect. An industry that was new to a young man a short time before employment, now becomes a dynamic entity, and he feels a part of it. A *good* training course brings the engineer into contact with the best men available for training work, and in this way has an excellent influence on his behavior that he will never lose. He unconsciously has built fences against the influences that can reduce his professional status and his individuality.

Healthy Attitudes

A good training program instills healthy attitudes. The young graduate has been carefully selected as a potential key man. He reports to work with high hopes to really wade in and build a reputation. These hopes are further elevated when he finds that his company is devoting the time and effort necessary to acquaint him with its policies, objectives, and all phases of operating procedure. He knows that he is, at best, only semi-productive and yet the company sees fit to pay him a salary while training him. Certainly this company must have plans for him!

Contrast this with the direct employment case; that is, hiring an engineering graduate for a specific job and plopping him into it with no training period. He starts becoming a productive employee the first day, and many years may pass before he learns, piece by piece, what the overall company operation is and how it is organized. He learns the hard way what facilities and services are available to him, and he may make many embarrassing mistakes.

He feels rather lost in a strange world during his first few years and does not realize where his opportunities may lie. In short, he is being almost pushed into that uncertain state of mind that makes him easy prey for influences not compatible with maximum professional development.

Frequently we hear the comment, "Fine, but a smaller company cannot afford much of what you were talking about and, therefore, cannot assume such responsibility." With this opinion I heartily disagree. As a matter of fact, a smaller company, taking only two or three graduate engineers per year, has the greatest opportunity possible to personalize their orientation and training period. Because the organization is small, closer contact with the men of experience and leadership in the organization is possible. Elaborate classroom set-ups, essential in the big company, are not necessary in the small one.

It would seem that the sincere employer should consider high-quality training to be an obligation, and professional growth a challenge. It is certainly one way to help our young engineers "do more quicker" and to that extent have the effect of increasing our numbers, thus offsetting our present shortage. I think you know that training has had a prominent place in Westinghouse operation for a long time, and I can attest to its effectiveness in making engineers a part of the productive organization quickly.

In addition to a good program of training, another measure employers can take to develop the individual is to urge their younger men to continue their education. Nothing enables a man to accomplish the maximum amount in his job better than good learning habits. His morale as a budding professional man is kept high if the employer encourages and assists him to supplement his college training by evening classes or guided self-study. In the graduate study programs we provide, in cooperation with ten universities, hundreds of our engineers are currently broadening their horizons through advanced education. Such study includes both technical and general types of courses, and the maturing and broadening effect is obvious to management.

We recognize that physical location, or other factors, may not permit all organizations to sponsor such formal programs of graduate study. However, encouragement and guidance from supervision will get many recent graduates started on their own in healthy self-improvement programs.

Another facet in the development of the individual employed in industry is his community life. Without going into detail, it can be briefly stated that this element of growth is the one most frequently neglected by industry.

Civic Development

Engineers have a reputation for being backward in civic programs and civic development. By the time the engineer reaches forty years of age, he probably occupies a position of respect and some prominence in his community. Why wait fifteen or twenty years to get started? Give the junior engineer in your company, or in your engineering society, or in your community a job to do! Make sure he is welcomed, introduced to his seniors, and that his efforts are recognized. Give him tactful guidance, of course, but then look out for his smoke, for the energy and enthusiasm of youth, once kindled, is a powerful driving force. The employer is in a key position to make the initial effort, but only a few really make an effort.

Finally, what happens when these young engineers begin to feel their professional oats; that is, when the transition period from academic life to practice is behind them and their horizons begin to broaden rapidly? At this point the employer has another obligation to youth. We must never be guilty of blocking a man just because he has a healthy boss. We must stand ready to recognize developed ability once it is present and keep the engineer whose "star is still rising" up to his limit in increasing responsibility. He will only continue to develop at a maximum rate if his work is a challenge to

his ability and experience, so that while he *can* keep his head above water, it is *not* without some struggle. If you are careful to place young engineers in jobs where continued challenge exists, you may be amazed to see how rapidly they grow to meet the opportunity that they, then, are able to see.

This leads us directly into the whole subject of management development. We do not have time to discuss this subject, but I will remark that our organization has embarked upon a comprehensive, formal program of management development and we are confident of important results. It will insure that the more mature men of potential recognize the horizons before them and it should guarantee that no man will be unprepared when opportunity is present. Through this management development program, we will make our men of potential more effective in their jobs and ready for increased responsibility quicker. This has the collateral effect of increasing our numbers through the broadening of individuals.

Conclusions

Our profession of engineering is responsible for most of the material progress in the world. With each technological innovation, the position of the engineer becomes more prominent, and the role of the engineer more necessary. In the nineteenth century, the engineer invented things and sometimes built things on a modest scale. In the past fifty years the engineer, besides inventing, became the expert on materials and processes, and thus created a mass production world, vastly complicated in nature. As we enter the second half of the twentieth century it is evident that the engineers are the ones who must be responsible if our accelerated pace is to be maintained. Furthermore, the engineers will have to run our enterprise, for as cited at the beginning, with each increase in the complication of our technical society, an engineering background becomes a requisite for more and more of the key jobs. Even today graduate engineers fill more of the top management jobs than people of any other one educational background. This trend will continue until a preponderance of all key men of management will be engineers.

What a tremendous responsibility this is! Our profession is rapidly ascending to a position where our members can, if they will, be the greatest single influence in the future of America. So we *must* keep our thinking broad in scope. We cannot allow our routine tasks to dull our vision. We *can* insure that young engineers receive guidance and work in an environment that will preserve the American system of enterprise and stop the fuzzy, foggy, economic thinking that would destroy our loftiest ideals. We can do a professional job of providing healthy internship for our junior members, including the proper introduction to their professional societies and their communities. Continued leadership of America can only be possible if our professional people are free to think and act as individuals in a free economy. Creative thought cannot endure in any other atmosphere. We owe the rising generation of engineers all the guidance we can offer, because they in turn are going to have to assume the responsibility of bringing the next generation into an even more complicated way of life.

Critical Evaluation of Counseling Received as Undergraduate*

By LILYAN B. BRADSHAW

Placement Director and Assistant to the Dean, Ohio State University

To anyone who has ever made a study evaluating opinions or impressions of human beings there finally comes that fateful moment when he stares vacantly at a pile of statistics, that has been so painstakingly assembled, and asks himself, "Now that I've got it, what have I?" Facts and figures are interesting enough in themselves but out of them must flow an analysis of information if they are to serve a purpose.

To begin with I hope I am not assuming too much in stating that no one who ever attended college escaped the effects of counseling in some form. As we grow older much of the textbook material we worked so hard over as students fades into a limbo of the forgotten past (those professors who wrote the texts will please forgive me) while the wise counsel and helpful advice we gleaned from kindly instructors along the way remain forever with us.

Student guidance and counseling are an irrefutable part of teaching. Whether a professor limits his contacts to the classroom or invites his students to his office for personal interviews he is serving as an advisor. The poet has said "There is a tide in the affairs of men which, taken at the flood, leads on to fortune." If ever there is a time in a human's life when he needs direction it is during the flood crest of youth, for it is then that his physical energy, mental keenness and acquisitive nature all assert themselves. Teeming as he is with these vital factors and eager as he is to employ them to his ultimate advantage, he recognizes the need of leaning on the counsel and wisdom of those more mature. It is for this reason that counseling received as undergraduates in our colleges is of the utmost importance and not something to be viewed as extra-curricular and insignificant.

This paper of course is concerned exclusively with engineers and a critical evaluation of the kind of counseling they have received as undergraduates in our universities. Because I have learned by association that engineering alumni of five minutes or fifty years are always most willing to look back on their college days and give forth quite freely with advice, I decided to contact a nationally representative group of universities and ask for the cooperation of the deans in soliciting their alumni for answers to a rather brief questionnaire. The schools selected extended from the east to the west coast and from Canada to the deep south. Out of 31 schools thus approached only five refused to participate and in most cases for understandable reasons. One other regretfully admitted it never had had any form of counseling hence could anticipate the unanimity of negative replies our solicitation would receive.

Each school was asked to select fifty alumni from the past ten years and send the questionnaire to them. From a total of 25 universities participating, 579 replies were received.

It was interesting to note the similarity

*A paper presented to the "Relations with Industry Division" of the ASEE. Dartmouth College, Thursday, June 26, 1952.

of proportionate answers which prevailed regardless of the size of school or region of location. In other words the comments, attitudes, and opinions of engineers toward college counseling seem to fall into a definite pattern which would have valuable significance to any university attempting to set up or improve its guidance program.

We found 311 had regular counseling while in college as opposed to 268 who did not. Such guidance was by a professor in 280 cases, by the dean in 102 instances and by the placement director for 75. Group meetings were the source for 71 while 34 claimed miscellaneous contacts. In 306 replies, counseling was voluntary and in 141, required.

Surprising Answers

Perhaps the most surprising answers were recorded to the question "Were you counseled during your freshman year concerning your choice of engineering as a career?" 244 answered "Yes" and 294 said "No." From this fact we judge that more than half of the students who elected to follow the curriculum of engineering were never questioned as to their suitability after they once entered.

Faculty members who do not limit their interpretation of duty to the classroom alone but who take time to become personally acquainted with their students are responsible for the overwhelming affirmative of 528 to 43 in answer to the question "Was there a member of the faculty to whom you could go to discuss your various problems with a feeling that you would be met with understanding and from whom you would receive a fair opinion?"

Our next question opened the doors wide to criticism as we inquired "Where did your school fail most in counseling?" In spite of the implied assumption that it had failed almost every group had alumni who flatly stated "It did not fail." But for those who took advantage of this opportunity to critically evaluate undergraduate guidance the greatest fault was laid in the first year where it was felt that aptitude tests should have been used and student interests and capabilities analyzed. Some regretted the lack of a well planned counseling system that extended not only throughout the entire college period but on into employment problems. Others wished a greater emphasis had been placed on the broad scope of engineering and its breadth of application. A few felt their faculties lacked sympathy or were not sufficiently experienced industrially. Some commented that there were too many students assigned to each counselor. Others decried counseling only for unsatisfactory work and the fact that their schools did not encourage faculty conferences.

Constructive criticism poured forth in reply to the question, "What suggestions do you have for colleges of engineering whereby they could do a more thorough job of counseling their students?" These answers were stated in a most frank and helpful manner with some participants even expressing their appreciation for having been solicited.

Desired Pattern

Guided by these comments, the following pattern seems to be the one most desired by engineers. Careful analysis will divulge the fact that it is sound, adequate and not out of the reach of any average university staff to effectuate.

First of all it was felt that guidance should begin in the high schools where early interests of young students could be directed in an exploratory way toward those subjects which are basic. Aptitude and intelligence tests were highly recommended during the senior year of high school and as a screening method prior to, and during, the freshman period. Close counseling on a compulsory basis throughout the first year of college was strongly advised with a follow-up for all students at the end of the second year to verify the sustention of engineering interest and capability. Lectures by industrial representatives should be open to lower classes and attendance encouraged.

Heavily emphasized by the majority was the need to develop a closer faculty-student relationship and those who re-

alized the time factor which limits this in many schools, went further by urging that each faculty member should be regarded as a counselor and his teaching load adjusted accordingly.

The importance of orientation courses, particularly in the first and last years, was pointed out. Also recommended were small, informal groups for counseling purposes in which alumni and upperclassmen could participate. It was felt that by this means, topics of mutual benefit could be developed and new ideas stimulated. This suggestion has particular value for the reticent type of youth.

Two comments that were almost unanimously made were:

1. School should give advice on entire field of engineering training, and
2. School should present frank and accurate picture of industrial opportunities for engineers.

It would seem that there is a lack of understanding on the part of students as to the broad aspects of engineering training even on the educational level—and there is also a definite confusion in many of their minds as to just what their specific expectations might be in connection with the adaptation of their training to industry.

Some felt that schools and industry should develop a closer liaison. As a part of this program the values of inspection trips and summer work experience were emphasized. Favorable comments were made on the help that could be derived from industrial representatives as frequent campus speakers. Schools were advised to urge the participation of young engineers in student activities as an invaluable means of broadening their scope of development.

Professional registration, and the part the college program should play in encouraging it, was strongly brought out.

The tremendous importance of courses in report writing and public speaking was underscored by many with only a slightly lesser number urging the value of the humanities for all young engineers.

Placement offices and their extensive functions as a service to students and alumni came in for a great amount of comment.

Strong Opinions

Strong opinions were voiced on what made for a good counselor and the remark "Avoid over counseling or poor counseling" appeared many times. Some alumni recommended that colleges employ full time professional psychologists or counselors but the majority seemed to feel that the most satisfactory type was found in the ranks of professors who had a broad outlook, a sympathetic interest in fellowmen, and a sound knowledge of industry through personal experience.

Covering as this study did, alumni from classes of the past ten years there is the chance that much has already been accomplished by American universities along the lines recommended. But whether that be true or not, it is helpful to know the weaknesses or fallacies in our counseling systems as now extant. Not many alumni can look back on their youthful years and say, "I did not need guidance." One of the greatest charms of youth is its willingness to listen (whether it acts as directed is often another matter) but the colleges, in serving as the training ground for young men and women, should assume the obligation of offering them the very best of guidance programs.

Integrating the Activities of an Agricultural Engineering Department in a School of Engineering*

By GEORGE A. MARSTON

Dean of Engineering, University of Massachusetts

I would like to make a few observations concerning Agricultural Engineering. In the first place, it is concerned with the applications of engineering principles to the agricultural industry, the largest industry in this country. The use of mechanical and electrical power, the design of farm structures, the development of processing equipment, and the planning of soil and water conservation are all a part of agricultural engineering. In practically all cases these problems have in the past been satisfactorily solved by using generally known engineering principles of electricity, the internal combustion engine, structural theory and the properties of materials. As a result, Agricultural Engineering has not demonstrated a need for or produced superior scientific knowledge. By comparison with Aeronautical or Chemical Engineering, other fields that are also relatively new among the family of engineers (and I speak as a Civil Engineer myself), we do not find that Agricultural Engineering has had to go to basic scientific research and to push back the boundaries of knowledge to find the tools necessary to solve its problems. Agriculture is the oldest livelihood of mankind. Many of its methods have been handed down from generation to generation. The opportunity to improve its procedures in our scientific age has been tremendous. Therefore, the Agricultural Engineer has found plenty of opportunity for practicing his profession almost without regard to his own scientific background. The result has been a tendency for Agricultural Engineering to be slow in advancing from the vocational to the professional level.

Breadth of the Field

There is another point that I wish to call attention to. Agricultural Engineering is a much broader field than either Aeronautical or Chemical. In fact, it is in many ways a more diversified field of engineering than any of the others, taking its structures from the Civil, machine design and the internal combustion engine from the Mechanical, farm power and equipment from the Electrical, and possibly food processing from the Chemical Engineers. Thus, it is unique among the family of engineers—sort of like the cosmopolitan child. This has its advantage but it makes Agricultural Engineering different—and to be different does not always win acclaim in our times!

I must certainly assume that most of you here today are interested in Engineering Education. You must recognize that Agricultural Engineering will not become a highly regarded branch of engineering until those of you in educational work put your own house in order. Service courses in refrigeration, farm motors, farm equipment and farm structures, without at least physics and mathematics as prerequisites,

* Presented at Annual Meeting of ASEE at Dartmouth College, June 26, 1952.

should not be called Agricultural Engineering courses. I suggest the term "Farm Mechanics" courses—however, call them what you will but not "engineering." The service offered by the "tire engineer" in the local garage is not far different from some of the work offered in these courses. That doesn't imply that they should not be offered for Agricultural students but don't confuse others with this engineering title. Agricultural Engineering curricula should include practically everything of the first three years of the Mechanical Engineering program: thermodynamics, applied mechanics, electricity, and of course all the physics and mathematics required of the other engineering curricula. In fact, I often wonder if Agricultural Engineering education shouldn't be at the graduate level, with a prerequisite a degree in M.E. or E.E. or C.E.—but let's leave that for future consideration!

Is Agricultural Engineering Needed

Some will question the possibility of attracting qualified students with such an undergraduate program. It has long been a problem of Agricultural Engineering curricula, and I doubt if it will be solved until your group "sell" themselves to the employers of engineers. Even the industries that manufacture primarily agricultural machinery have not been particularly vocal in expressing a need for this special kind of engineer. The trained civil, electrical or mechanical engineer with an interest in problems of agriculture finds himself with but slight handicap compared to the agricultural engineer. Possibly this is due to the poor scientific training some of our agricultural engineers have had in the past.

Now, with this background as I see it, what about the integration of the activities of an Agricultural Engineering Department in a School of Engineering? There are several "selling" points that make such a department a desirable addition to an Engineering School. In the first place, this field brings almost unlimited problems of the applications of engineering principles which can be suitable investigation projects for staff members of all departments and at all levels of professional background. Often the instructor or young assistant professor finds it difficult to get started on a research project which he feels has practical value and which has not been exhaustively explored before. Agricultural Engineering provides plenty of opportunity for the young engineer to practice his profession.

Furthermore, agricultural engineering brings a spirit of service which is not always found in other departments. The Agricultural Extension and Experiment Station work of the agricultural engineering departments tends to broaden the outlook of staff members. Consulting work is normally a part of the activities of the staff of an engineering school, in some encouraged and in others tolerated. Yet I know of no group that does more consulting work than the agricultural engineering departments through their extension activities. The fact that this is generally state- or federally-financed creates a spirit of service to the community at large that seems to me is more apparent in Agricultural Engineers than in others. There can be built up through the needs of this department a cooperative attitude on the part of all units of the School of Engineering.

Training and use of Staff

Other departments will readily accept the Ag. Engineer as part of the School if staff members are well qualified. Department heads have got to be aware that their colleagues in engineering schools are critical of the Agricultural Engineer who by training and experience and accomplishments is really a good farm mechanic —valuable as he may be. There obviously cannot be two standards of qualifications for the professional ranks in the same school—one for Agricultural Engineers and one for the other fields. This often means that the service courses for Agricultural majors will have to be handled by non-engineers, whose advancement ceiling

is lower than the engineers, or by instructors. Neither situation presents a serious problem if properly handled. I am convinced that the instructor who must offer refrigeration, for example, to dairy majors who haven't had physics will have to do a real teaching job. This experience will be fine if he advances to the professional subjects.

The occasional use of Agricultural Engineering staff members to handle engineering science courses, such as applied mechanics and strength of materials or engineering drawing and surveying, is a technique that can be used in integrating this department into the School. It can create a spirit of cooperation in the overall educational training of the engineers that will be most helpful.

Conclusion

Based upon five years of experience and a real interest in seeing Agricultural Engineering develop, I feel that the logical place for such a department is in a school of engineering. There are administrative problems involved but the ground is fertile for truely professional growth of Agricultural Engineering, which I am sure you all want.

College Notes

The story on the inclusion of philosophy courses in the **University of Detroit** curriculum announces an Arts College "invasion" somewhat unique in the history of engineering education. This is the first time an engineering college has placed such stress on philosophical principles.

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Dr. Alfred W. Doll, Professor and Head of the Department of Physics at **Pratt Institute**, has been named Acting Dean of the School of Engineering to succeed H. Russell Beatty. Dr. Doll received his education at the University of Pennsylvania, Columbia University, and New York University. He is active in the ASME, the American Institute of Physics, ASEE, and Tau Beta Pi. He has been a member of the faculty of Pratt Institute since 1925, and has headed the Physics Department since 1938. Mr. Beatty, who has been at Pratt since 1937, will assume the Presidency of **Wentworth Institute** in Boston on July 1. He is a graduate of the University of Maine and New York University, and an experienced management engineering consultant. He holds membership in ASME, ASEE, and Tau Beta Pi.

Two new engineering buildings were dedicated on March 26, 1953 at the **Agricultural and Mechanical College** of Texas. These were a Texas Engineers Library building and an engineering classroom and laboratory building.

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Appointment of Dr. Albert G. H. Dietz as Acting Head of the Course in Building Engineering and Construction at the **Massachusetts Institute of Technology** has been announced. Beginning July first the course will operate as part of the Department of Civil and Sanitary Engineering and its instructing staff will be included in this department.

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Appointment of Dr. William A. Patterson as dean of engineering at **Fenn College**, Cleveland, Ohio, has been announced. Patterson, Fenn registrar since 1946, was appointed associate dean of engineering in February last year after former engineering Dean G. Brooks Earnest became Acting President.

Distinguished Professor at the University of Kentucky

By M. M. WHITE

Dean, College of Arts and Sciences, University of Kentucky

The problem of recognizing merit and holding personnel is met in all professions and in all fields of industry. Financial reward is always but one of many factors determining a man's choice of jobs and in our Universities it is a relatively weak element. Fortunately, opportunity for service, security, and recognition are desired more than material gain. Were this not true, we could not hope to hold our outstanding young men for we cannot compete with government or with industry in monetary inducements. As a recognition of service and ability the College of Arts and Sciences of the University of Kentucky elects each year from its membership the "Distinguished Professor of the Year."

Privileges and Obligations

The honor allows the man elected to have one semester on full salary free from all academic routines. It permits him complete freedom to develop his interests in his own way. He may spend the semester in his laboratory; he may gather research material in far places; he may go around the world; he may write a book in Florida or in California. During the nine years that we have had the program each of these things has been done by some professor.

Following this semester the professor must deliver to his colleagues and the public a lecture based on his voluntary activity. Every effort is directed to make this lecture and the reception following it an occasion of interest to the academic community and of honor to the Distinguished Professor. A printed statement of the professor's personal history and election to the honor, with mention of the title and date of the lecture, is mailed to approximately four hundred individuals in other institutions. This list varies from year to year, being comprised mainly of persons interested in the field of the lecturer.

Method of Selection

The Dean of the College of Arts and Sciences appoints a committee of five staff members of professorial rank to conduct the election and arrange for the lecture. Usually staff members who have previously held the honor constitute the majority of committee members.

In the spring, the committee sends to each faculty member a request for one nomination selected from a list of all individuals holding professorial rank without administrative duties. The request is accompanied by a list of eligible persons, a list of professors previously honored and a short statement of the basis upon which nominations are to be made.

After the nominations have been received a ballot listing the highest three or four nominees is sent to the voters. If other ballots are required to give one nominee a majority, the nominee receiving the fewest votes on a given ballot is dropped from subsequent ballots.

When one candidate has received a majority of the votes, he is so informed by the chairman of the committee. He then makes arrangements with the Dean to be released from his usual duties during the

fall semester and selects an approximate topic and date for his lecture to be given during the spring semester.

Functions Served

1. The Distinguished Professorship promotes the prestige of the *teacher* among the University personnel. During the nine years that we have bestowed this honor the recipient has always been a man whose teaching ability was rated high by his colleagues. Research has played its part in the choice but has not been the primary factor in selection. You have probably noticed that a member of a University Faculty, asked by a stranger what he does, is more apt to say that he is a physicist, an engineer, or a psychologist than that he is a teacher. Isn't this because he prefers to identify himself with the group which he thinks has the higher prestige? Yet we have great faith in the value of the teaching profession; we make sacrifices—certainly financial ones and often others, too—to belong to that profession. There is delight in occasionally producing a really outstanding student. There is pleasure in having a good or average student thank you for what you have contributed to his learning whether by inspiration or by solid factual material. All of us have enjoyed these intangible values. But public recognition brings a zest of its own.

2. Election to this honor gives security and pride of accomplishment to the recipient. It is an honor given by one's colleagues with a secret ballot. Administrative approval, increase in salary and rank, offers from other Universities are desirable but this indication of confidence by fellowworkers is something quite different and probably more pleasing.

3. Not only the immediate election but the knowledge that there is to be one each year encourages faculty members to know and appreciate workers in other fields. In this age of specialized training and departmental organization, we must strive constantly for cross fertilization of ideas from many departments.

4. Although the Administration has nothing to do with the election of the Distinguished Professor and little to do with the implementation, it receives benefits also. Members of the Administration see individuals from a different and unfortunately limited point of view. Knowing the evaluation of a man by his colleagues is of great value.

Another advantage to the Administration is that destructive criticism may be reduced and scapegoating (with the Administrator the goat, of course) may be decreased. Constructive criticism is, of course, a very different matter.

5. A final and important advantage of the Distinguished Professorship is the Faculty participation in important decisions. To participate in the election gives a feeling of belonging to the group. Each individual is a vital part of the whole.

The whole program of the Distinguished Professorship depends by its nature upon faculty initiation, interest and activity. Such a program implemented by the Administration would be without meaning—or at least of very different meaning.

Anything that will increase the active participation of the professor in the determination of the policies of our colleges is valuable. One is constantly delighted with the rich, lively, and exciting inventiveness and ingenuity of the so-called absentminded professor.

The Role of Professional Licenses in Engineering Education*

By EDWARD J. NUNAN

President, New York State Society of Professional Engineers

Those men who are about to embark upon Engineering as a career must expect inevitably to face the matter of a professional license. All 48 of the States as well as the District of Columbia now have a Professional License Law and the earlier in his career he obtains this license the better off he will be in the end. While it is true there are a few exceptions where licenses are not required, such as Federal employees, certain State and Municipal employees, employees of Corporations engaged in interstate commerce, employees of Corporations under the jurisdiction of a State Regulatory Body and individuals working under the direction of a licensed Engineer, it is my opinion that many of the exceptions are rapidly becoming outmoded. As a matter of fact I know that one of the largest Corporations in this country has decided upon a policy that will not permit any of their Engineering employees to be designated by the title Engineer nor will they permit them to do any Engineering design or construction which has to do with the safety of the public unless they have a Professional License. Many State, County and Municipal jobs now have a Professional License requirement. As a matter of fact the New York State Department of Public Works does not permit a man to take the Civil Service Examination for any grade including and above that of Senior Civil Engineer without a professional license even though he may have a college degree. Many members of the Department of Public Works who have had long employment and neglected to get their professional licenses are barred from promotion because at this late date they will not take time to study and prepare for a professional license examination.

Increases Stature

A professional license always increases a man's stature even though he may be holding a position which at the time does not require a license. It has benefited Engineering education through the necessity for accrediting Engineering College. Men graduating in law and medicine are required to take their license examinations immediately upon graduation from school, why not the Engineer.

New York is one of the states which has established a plan under which graduates from registered courses may take their preliminary examinations when they are best fitted to do so. Under this plan they may take parts one and two of our examination immediately upon graduation. These are the preliminary examinations and upon passing them the man is granted a certificate as an Engineer in Training. After completing four years of experience of a grade and character satisfactory to the board, Engineers in Training may then take part three. This is the final examination for license and upon passing it the man is granted his professional license. This plan was adopted to permit young Engineers to be examined in the basic

* Delivered at the Middle-Atlantic Section Meeting, A.S.E.E., at Manhattan College, Dec. 6, 1952.

principles of the profession while their training is still fresh in their minds. Previous to the change in this law, no one was permitted to take any of the examinations until they had acquired four years of satisfactory experience at which time they were permitted to take all three of the examinations. Under the new system a much higher percentage of candidates pass than in the cases where they took the entire examination at one time, after being out of college a minimum of four years. Those students who graduate in Engineering and expect to follow Engineering as a profession will eventually have to face the matter of a professional license and the time to take that examination for a license is immediately upon graduation.

The New York State Society of Professional Engineers as well as the National Society are doing everything within their power to see that men graduating in Engineering Courses are given all the information necessary to enable them to obtain their licenses. In many cases we do not have the opportunity to reach all of the students who should be so advised and it seems to us the proper way to handle this is through the Engineering Schools themselves. Many men are now graduating without knowledge a license is necessary. I can think of no group of Engineers who should be more interested in the future of the Engineering Profession than those doing the teaching in our colleges today. They above all should be as much interested as any one in an Engineering License Law and its strict enforcement. In addition they have the complete confidence of all of their Engineering students and they above all should be the ones who should stress the advantages of an Engineering license and the methods of obtaining one. I know that here at Manhattan College and at many other schools a great deal of effort is put forth to instruct the students as to the method of obtaining their license and also advised as to the E. I. T. licenses, when the examinations are to be held and give them every encouragement and advice as to what they will have to expect in the nature of an examination. I am firmly convinced that every Engineering School in the country should follow these lines of thought. It is the hope of our Society that eventually all of those teaching Engineering in colleges will recognize the importance of obtaining a license of their own and in this way impress upon all of their students the benefits to be derived from a professional license which in turn will make Engineering the profession it deserves to be.

Unionism

There are many more advantages to be gained by having a professional Engineer's license or an E. I. T. certificate in that it serves to protect our profession from the restrictive practice of Unionism when its productivity must be greater than ever before, and it is the thought of many Engineers in Industry that if all of those men graduating in the profession had an E. I. T. Certificate when they apply for employment the Union problems would be much easier solved. The Taft-Hartley Act of course eliminates anyone with a Professional Engineering license from having to join any collective bargaining unit. I am firmly convinced that with proper education this can also be made to apply to the E. I. T. The policy of the National Society of Professional Engineers regarding collective bargaining by professional employees is as follows:

"It is definitely unprofessional for a Professional Engineer professionally employed voluntarily to join a heterogenous Union dominated by or obligated to nonprofessional groups. The individual responsibility and independent judgement required of a Professional Engineer are incompatable with the regimentation fundamentally inherent in Unionization. Nothing in this statement shall be construed as a criticism of Engineers who may be forced to join a labor union against their will but Engineers in this predicament should seek to extricate themselves by due process of the law.

"Nothing in this statement of principle shall be construed as a criticism of Engineers in Training who voluntarily join a labor union when as a step in their practical Engineering training, they are temporarily

employed in nonprofessional or subprofessional work where their fellow workers are organized. When promoted to professional responsibilities however, the Engineer cannot continue in his labor union affiliation without sacrifice of professional status."

Much trouble has been experienced along these lines and one large industry that I know of has, at present, a strike which is forcing many E. I. T. men to be temporarily unemployed through no fault of their own. I would like to stress at this point that these men are not forced to join a union. However, unless they are engaged in a supervisory capacity or in a very special job they become automatically a part of the office force of this organization which is controlled by a Union comprised of office workers. This Union comprises all of the office help such as stenographers, file clerks, blueprint machine operators, office boys, etc. In other words, it is a bargaining unit which comprises the entire office force of this organization outside the few of those employed in a supervisory capacity and of course includes those young Engineers who are employed in various sub-professional jobs and in Training Courses. As I said before it is not necessary for these young Engineers to join the Union; nevertheless they are a part of this bargaining unit and whether they join or not they are automatically a part of it and to a large extent controlled by it and if a strike is called they are out of employment also. Some of the Engineers have E. I. T. Certificates, others, do not although they do have a College Degree in Engineering. Again all are subjected to the high pressure tactics of various Union leaders and under these conditions are apt to get some erroneous ideas of their future.

Conclusion

For the reasons I have stated I believe that if all Engineering graduates had an E. I. T. Certificate when they applied for employment that we then might be able to do something for them. Our Engineers, due to their training, should be building toward future positions where their own individual imagination, abilities, and initiative will enable them to take over an executive position. Certainly there is no place for this type of thinking in any collective bargaining group.

Forty per cent of industrial management is Engineer trained replacing both the lawyer and the banker in top industrial posts. Engineering is and no doubt will continue to be our country's third largest profession.

We in the National and State Societies of Professional Engineers are endeavoring to do everything that we can to increase the professional conscienceness, ideals, and rewards for the Professional Engineering Career. We cannot do it alone. You, gentlemen, charged with the education of our future Engineers can do a great deal to help the profession. With your cooperation I am sure we will be successful.

College Notes

To bring industrial engineers current information in the rapidly expanding field of transistors, the **Massachusetts Institute of Technology** will offer a Special Summer Program in Transistors and Their Applications from July 20 to 31 during the 1953 Summer Session. The aim of the program, announced by Dr. Ernest H. Huntress, Director of the M.I.T. Summer Session, will be to define those areas in which the transistor may have immediate application and to make some prediction of its future. Approximately one-fourth of the M.I.T. summer program will be devoted to a development of the theory of the operation of transistors, starting from familiar physical principles.

Training in Research*

By FREDERICK C. LINDVALL

Chairman, Division of Engineering, California Institute of Technology

The colleges and universities of the world during the past hundred or more years have provided an environment which has led to nearly all of the fundamental science upon which our present-day technology is based. With very few exceptions, the great names in science and the discoveries and principles with which those names are associated are those of professors and their students in the colleges and universities. Does current sponsored contract research conform to the academic objectives of training of students and the production of new knowledge?

Industrial research and government laboratories contribute to the search for basic knowledge, but in view of the principal objectives of the laboratories of this type, we must expect them to be directed toward application and development and, therefore, we must continue to look to the colleges for our major advances in fundamental science. This in itself is sufficient reason for emphasis on research and upon the training in research which comes through the efforts of the professors working with their graduate students. These academic research efforts, in the past unorganized as they were and often poorly supported, have been successful both in output of useful results and in the inspiration given to students to continue the quest for knowledge. This method in basic science is a priceless asset which we must support and at the same time must protect against the encroachment of development work with its inherent direction. As Dr. Conant has said: "There is only one demonstrated method of producing basic knowledge; that is, by picking men of genius, backing them heavily, and leaving them to direct themselves."

A second reason for research in colleges is that teachers who engage in a reasonable amount of research maintain their professional effectiveness and inspire their students with the spirit of freedom of inquiry.

A third reason, which is intimately related to the first two, is that the students learn research, its spirit and techniques by seeing research done and by participating in the research program, first as aides or apprentices, and then as advanced graduate students working as nearly as possible as independent investigators. Additional reasons for doing research are those of public service to the local community, to the state and the nation, of assistance to the military, of cooperation with industry, —all of which are valid under qualifying circumstances, but which are sometimes invoked as justification for work which might be better called "engineering development."

A Learning Experience

Training in research is a learning experience, perhaps more subjective than some of the more formalized courses of study, which involves an awakening of curiosity and a spirit of inquiry, coupled with methods and techniques. This spirit of research and the leadership which fosters it are prime factors in research training: problems, facilities, organization are secondary. A real investigator with "sealing wax and string" equipment can give

* Presented at the Annual Meeting, A.S.E.E., at Dartmouth, June 26, 1952.

a student far more than could be had from some types of elaborately implemented group effort rightly referred to as "organized mediocrity." The same good leadership can bring out for the student facets of a problem which are contributions to basic science, although the objective of the problem, itself, may be applied research or development. A Langmuir might develop a dishwashing process and yet concurrently make vital contributions to basic knowledge of surface physics and chemistry. The man who is doing the work has as much to do with the character of the research as the specific stated problem.

Sponsored research in colleges today has reached enormous proportions. Some of this work has little or nothing to do with the academic program. In many instances, it is harmful to the teaching program because it dilutes the efforts of the teaching staff and brings to the campus full-time employees who do no teaching and occupy space which is then not available for normal graduate student use. Frequently, large-scale projects operate under military security in separate buildings and those members of the faculty who must spend time there are virtually inaccessible to the students. Other classified projects in the regular campus buildings are objectionable because they require the blocking off or isolation of corridors or wings, and individual rooms bear the inhospitable notice, "Restricted Area—No Admittance." Such activity is not in the spirit of academic freedom, of discussion, publication, or interchange of ideas. Except for a few who may be employed as part-time workers, students simply do not have access to this work, do not see the research in progress, and cannot be told about it by the professors. Such projects teach no research.

Fortunately, better sponsored research can be had if discrimination and determination are used in the acceptance of contracts so that work of fundamental and basic type can be done freely on the campus without restriction on publication or use of graduate students. Such sponsored work can provide the equivalent of graduate research assistantships, actually compensation for services rendered on those government funds which do not permit scholarship grants. Such association with research projects can be real research training, if the work is done by the faculty members and their students in the best academic tradition, rather than as an highly organized effort with administrative procedures inappropriate to academic life.

High dollar value of the research contract need not lead to an excess of administration. One of the largest contracts in Physics at the California Institute of Technology—approximately $100,000 a year—includes a variety of studies in nuclear physics with no administrative machinery at all. The responsible professors are to be found not in their offices, but in the laboratory and, except for age, are indistinguishable from the graduate students. This effort has been highly successful in its output of fundamental knowledge.

Another type of sponsored research on the CIT campus operated for several years with highly organized administrative procedures. The professors involved spent most of their time "directing" research, rather than participating in it. The equipment was elaborate and the work was done almost entirely by full-time non-academic employees. The whole atmosphere was inhospitable to graduate students, although they were encouraged to participate in the work. Instead students preferred to work on other things directly and intimately with professors in the personal, informal way in which academic research developed, rather than in the impersonal, organized directed effort. We have subsequently substituted some anarchy and chaos for this particular organized administration, encouraging the faculty members to work directly with their projects and are now successfully integrating graduate students with the several programs.

Over-expansion in Staff

The availability of money for sponsored research, particularly from government sources, has tended toward over-expansion in staff and facilities in the colleges. In many of our schools the best teachers and research men have become so involved in project work that too little time is available for the personal student relationships which are needed for the best research training. Some colleges have used project money as a way of augmenting faculty salaries to hold personnel. Conversely, in order to meet project commitments, new personnel have been employed, sometimes with the added inducement of a faculty position for its prestige value, with or without any teaching. The tenure commitments, stated or implied, to these new faculty members may present serious problems for the future, as project money becomes less readily available.

Just as the faculty salary schedule inflated with contract funds is a serious problem, expansion with elaborate facilities is potentially hazardous. Large apparatus, such as wind tunnels and water tunnels which require crews for their operation, certainly are luxuries no college can afford if government support is not available. The fact that these facilities are government properties, which probably could not be removed, imposes some obligation on the schools to make them available for government work which, in the absence of easy project money, will be on the government's terms. The colleges may find themselves with operating contracts for the performance of work which is planned and directed by some government agency. Moreover, these larger facilities are difficult for graduate students to use, even under present funding possibilities, so that, unless the work is very carefully plannned with the student's interest in mind, little of value in the teaching of research will accrue to the student. He may find employment which will help him maintain himself in school and he may learn some things by osmosis, but he will lack that essential feeling of participation and the opportunity to follow some line of inquiry which is his own.

At the California Institute of Technology, the Division of Biology, unhappy about student participation in sponsored research, has stated that graduate students may not be employed on sponsored research, but instead be granted scholarships which will permit them to pursue research which is simple, self-contained, and individual in character. The spirit behind this principle is that a student sharing in a sponsored research program with other students and under faculty supervision will not have the opportunity to use his own initiative and develop as a well-rounded research man. The rest of our campus does not share completely this belief, but recognizes its merits.

Summary

In summary, it may be stated that sponsored research which does not integrate with the fundamental objectives of an academic institution in the furtherance of basic knowledge and the teaching of students is out of place on a college campus. Uncritical acceptance of sponsored projects may lead to poorer teaching and mediocre research. Wise use of the opportunities for sponsorship allows the colleges, working beyond their own resources, to meet their responsibility, far more effectively, for the search for new knowledge and the training of new research workers.

TIMELY TIPS

The Optional Problem—A Teaching Device

By WILLIAM K. VIERTEL

Instructor, State University Agricultural and Technical Institute, Canton, N. Y.

One of the most serious criticisms made of modern education is that it often leaves the superior student unchallenged while the instructor gives most of his efforts to the average students who make up the majority of his classes, particularly at the freshman level. The device of the optional problem is one way in which superior students can be stimulated to do their best on work which challenges them. The writer has used it successfully over a period of ten years, in various technical courses.

Optional problems may be assigned whenever the situation is ripe for them. This may be when the topic involved is taken up in class; or it may be when suitable motivation arises. It is explained to the class that the word "optional" means what it says: students do the problem or not, as they wish. There is no penalty for not attempting it, and no penalty for attempting it and getting it wrong. For anyone who gets it right, appropriate credit is given. It may be added that students who can do these problems usually do not need any extra credit. A reasonable time is allowed to get the problem done, remembering that students have their regular work to do, in this and in other courses.

It is required that students append to the solution, when submitted, a signed statement that the work has been done honestly. The reason for this is mostly psychological. The writer has examined several hundred papers on numerous different problems, over a period of years, at two different colleges (one of which had the honor system and one did not), and has yet to see any attempted solution of an optional problem which did not bear the unmistakeable stamp of the personality of the student who submitted it.

Optional problems must be carefully selected, and should not be given too often. The ideal optional problem is one which very few students are likely to get right, so that they will have a feeling of something unusual achieved if they succeed. The writer has always insisted on extra-high standards of accuracy and neatness in these problems. Errors in reasoning or computation, or careless presentation, cause rejection. Errors of judgment, in some cases, are considered permissible. An example of a problem of this type is included below.

The enthusiasm with which superior students attack these problems is a continual surprise to the writer. He considers this proof, if any be needed, that students do accept their share of responsibility in the educational process, and will respond to a challenge. Students have said to the writer, "These optional problems are aggravating. I get interested in them and spend so much time on them that I don't get my other work done."

Following are a few examples of optional problems the writer has used in teaching freshman engineering mathematics.

(1) A stone is dropped in a well, and it is found that exactly 4.0 seconds (by stop-watch) elapses between the dropping of the stone and the time the

splash is heard. Assume 1100 ft./second as the speed of sound. Calculate the depth of the well.

(2) A well-known parlor game is to ask someone to write down a three-digit number. (The first digit must not be the same as the last.) Have them write the number, reversed, immediately above or below the original number. (See example.) Subtract the two. Then write the difference, reversed. Add the last two numbers. The result is always 1089.

```
  712
  217
  ---
  495
  594
  ---
 1089
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The problem is to give a general proof that the result is always 1089.

(3) A car travels d miles, from Smithtown to Jonesville, at an average speed of 40 miles/hour. It makes the return trip at an average of 60 miles/hour. Find the average speed for the round trip.

It was on this problem that an error of judgment was considered permissible. If a student worked with decimals instead of common fractions, his answer did not come out exactly correct.

(4) One of numerous devices to convert Centigrade temperatures to Fahrenheit, *or* the *reverse,* is to add 40 to the given temperature; multiply by ⅝ in the first case or ⅝ in the second; subtract 40 from the result. Example: convert 40° Centigrade to Fahrenheit. Add 40, giving 80. Multiply by ⅝, giving 144. Subtract 40, giving 104° F.

The problem is to prove that this method is theoretically sound.

(5) Derive the rth term of the binomial expansion $(a+b)^n$. Can be used only if the text-book used does not give this.

(6) Explain in terms of logarithms the use of the right index of the slide rule in multiplication.

(7) Prove that

$$\log_b a = \frac{1}{\log_a b}$$

(8) Prove the formula for sin $(A+B)$ and cos $(A+B)$ if either A or B is greater than 90°. (Various cases.)

(9) Prove that

$$\sin A + \cos B = 2 \sin\left(\frac{A-B}{2} + 45°\right) \times \cos\left(\frac{A+B}{2} - 45°\right)$$

(10) Given a regular tetrahedron, edge 2. Let a plane be passed through one edge of the tetrahedron in such a way as to bisect the tetrahedron. Find the angles of the triangle so formed.

(11) Calculate how to lay out a sector of a circle so that when formed into a cone it will have any given base radius r, and any given altitude h.

College Notes

A plan to aid industry through fundamental research in engineering and science has been devised at **Carnegie Institute of Technology.** A regular and scheduled information service has been set up by the institution. This information service makes available to cooperating companies reports on current research projects undertaken by individuals of the engineering and science departments. Cooperating companies are those organizations which give financial support for research to Carnegie.

THE T-SQUARE PAGE

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DEVOTED TO THE INTERESTS OF ENGINEERING DRAWING

JOHN M. RUSS, *Editor*
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January 2, 1952

Prof. B. L. Wellman
Worcester Polytechnic Institute
Worcester, Mass.

Dear Prof. Wellman:

Your report of the East Lansing meeting, including as it did your invitation for expressions of opinion, has prompted these remarks. Having spent three years teaching engineering drawing and nine as a design engineer in varied industries, I feel that my views might be of interest to men currently engaged in teaching.

Are integrated drawing courses more pedagogically sound and more efficient of time?

I am not certain what is meant by an "integrated" course but I presume that this means, for example, that structural drafting should be taught by the civil engineering department in conjunction with the structural design courses rather than as a drafting course given by the drafting department. If such is the case, my answer would be "No."

There is almost irresistible tendency for the mechanics of drawing to become secondary to the theory involved. Drawings degenerate in time to sketches on quadrille paper. In such a course, the final examination almost invariably stresses the theory which has been studied. It is difficult to test a student's improvement in drafting ability by a mere final examination. Only a drafting course which lays heavy emphasis on the grades for the drawings submitted serves to drive home the idea that the development of drafting skill of a professional caliber is one of the prime objectives of engineering training.

How can we convince the administrations that descriptive geometry is a vital part of an engineer's education?

I have of course encountered dozens of situations where my knowledge of descriptive geometry saved the day. But more important, I have also had several dramatic experiences where a design problem was mauled by so-called design draftsmen and where the office fat was pulled out of the fire by an engineer who had mastered descriptive. These instances, although they do not occur daily in an office, occur frequently enough to cause run-of-the-mill draftsmen and unappreciative employers to hold their graduate engineers in greater esteem.

Most schools offer only one semester of descriptive geometry. At the City College of New York, where I was an instructor from 1946–49, two semesters of descriptive were required; this, I feel, fills the need of our future engineers more adequately.

What to do with students who have had drawing in high school?

My feeling is to ignore this superficial training and require these men to do the same work as those students entering with no previous training in drawing. I say this because I numbered among my students many graduates from a local technical high school which has a national reputation. These students had four years of drawing training in high school and openly expressed resentment upon being informed that they would be re-

quired to take the regular college course. I have heard such expressions in my classroom during the first few meetings and I used to deal with these dissidents by directing leading questions to them in the course of the first few lectures. After repeated confessions of ignorance, the smoldering resentment was dissipated and the boys buckled down to do a swell job.

The fault of course did not lie with the boys. I attributed the blame to their high school teachers who had led them to believe that high school training in mechanical drawing is the equivalent of college training in engineering drawing. Until I see dramatic proof to the contrary, I will continue to reject that idea. The principal reason why high school training cannot match the caliber of college training is that high school drawing is necessarily confined to simple objects requiring no preparation in descriptive geometry, and secondly, high school teachers generally do not have the close connection with the preparation of engineering drawings that the college teacher has had.

As a means of convincing the administrations how important engineering drawing is (I would suggest that the deans organize seminars and conferences with leading engineers in the community at which time they can discuss the general question, "How can we train our young engineers to turn out professional-looking drawings?" Interest should be high because almost all offices pride themselves on their drawings. The expressions by practicing engineers will do much to convince the deans and presidents that drafting ability and mastery of descriptive geometry represent for engineers, not merely mechanical skills, but necessary professional skills.

The importance of drawing itself in relation to the professional status of engineers.

We have witnessed in recent years an attempt by some educators to relegate engineering drawing to a back seat on the campus. The result is that very few colleges, if any, can point to their graduates and say, "There is a group of young engineers who can step into any drafting room and do the professional job that is required of them." I have witnessed dozens of times the almost tragic first effort at drawing by a young graduate from an accredited college. Viewing the grossly amateurish first drawing, the employer feels justified in offering the young engineer the meager salary which is current, because the average youngster simply cannot pull his own weight in the office.

It seems to me that in this connection we engineers ought to borrow from the medical schools. One never hears of a young medical graduate being unable to tie a bandage, administer a hypodermic, perform simple surgery, etc. The lay public cannot differentiate between young and old doctors in the performance of elementary professional skills. The same ought to hold true for engineers. Our young graduates should be able to turn out professional looking drawings as well as the older, experienced men. Until such time, the status of the young graduate in an office, for several years after graduation, will be below that of the technical school-trained draftsman working next to him. And his salary will be, and is, correspondingly lower.

Those of us who are concerned with advancing the profession both economically and socially must keep in mind that unless we succeed in turning out a better college product, starting salaries in the profession will continue to be below that of current union rates for common labor. It will continue to require fifteen or more years of professional experience until the engineer achieves a financial status commensurate with the services he renders.

An engineer who cannot put his design down on paper in conformity with current drafting standards can do only half a job. Let us train our students to do a whole job.

Very truly yours,

David Singer

Minutes of Executive Board Meeting*

A meeting of the Executive Board of the American Society for Engineering Education was held on Monday, April 20, 1953, at the Northwestern University, Evanston, Illinois. Those present were: W. R. Woolrich, *President*; M. M. Boring, J. H. Lampe, E. A. Walker, W. C. White, *Vice Presidents*; C. L. Skelley, *Treasurer*; A. B. Bronwell, *Secretary*; K. B. McEachron, Sr.; and B. R. Teare.

Annual Meeting

The Secretary reported on the progress of Society activities and the plans for the Annual Meeting.

Nominating Procedure

The procedure for nomination of officers was discussed by the Board. It was suggested that the balloting procedure is not too well-known to the membership and that a summary of this procedure might be published in the May issue of the JOURNAL.

Quarterly Report

The Treasurer presented the statement of Receipts and Disbursements for the third quarter ending March 31, 1953. It appears that the income for the year will be from $2,000 to $3,000 over budget. Expenses will also be higher than budget, owing to an increase in printing costs of the JOURNAL OF ENGINEERING EDUCATION, the rising cost of supplies and sundry printing, etc. The hiring of an assistant secretary and an additional office secretary, as well as salary increases, have increased costs of operation. It appears at present that the expenses will be very close to income for the current year, although there may be a deficit. The financial outlook for next year is somewhat better, owing to the success of the Associate Institutional Membership drive and the increased advertising revenue.

Report on Growth of Engineering Unions

Mr. Karl B. McEachron, Sr., General Electric Company, presented a summary of the problem facing the engineering profession, resulting from the growth of labor union activities in this field. He discussed the positions taken by EJC and NSPE in testimony before Congressional Committees, relating to amendments to the Taft-Hartley law. He stated that Engineers' Joint Council had refused to include in its testimony the advocacy of the principle of "Freedom of Association" which would give the engineers an additional degree of freedom through operation in company associations. He emphasized the fact that the present Taft-Hartley Law draws an Iron Curtain between management and labor which is not in conformity with professional precepts. He also stated that labor unions cannot long survive without expanding their activities into other areas of interest to engineers and that this would ultmately result in their attempting to take over the technical programs and building themselves up as a "Unity Organization" for the profession.

He reviewed some of the plans under consideration by his company and other companies for developing organizational channels, improving the professional status of the engineers, and improving their working conditions and facilities. This will be the subject of the Tuesday morning General Session.

Several points were raised by Board Members. It was pointed out that a substantial number of engineering graduates, probably those most vulnerable to unionization, are not associated with engineering societies and therefore are not reached by activities of the engineering societies in their attempt to forestall the growth of unionism. It was also pointed out that

the lack of spread in the salaries of engineers is cause of considerable discontent, since beginning engineers are hired at salaries not too much lower than those of engineers of 10 to 15 years experience. The greatest impact of unionism on the engineering profession would be a leveling down process which would destroy individuality and outstanding achievement. Also, the better men are inexorably "swallowed-up" in the process of unionization, regardless of whether they want it or not.

An article written by President Woolrich on this subject, entitled "The Engineering Profession—Leveling off to Mediocrity or Ascending to New Heights" was published in the April issue of the JOURNAL OF ENGINEERING EDUCATION. This article was forwarded to the Engineers' Joint Council to be sent to all members of the Engineering Manpower Commission. The National Society of Professional Engineers published this article in their Journal. Also copies were sent to the Deans of Engineering Colleges, since the projected plans of the engineering union organization contemplated setting up student organizations in engineering colleges.

Engineers' Joint Council

The question was raised as to the procedure used by EJC in formulating its policies and presenting testimony before Congressional Committees. It was pointed out that EJC cannot properly represent the Engineering professions unless all major policy matters are referred to the societies for their study and actions. Otherwise, the Unity Organization becomes a separate entity with opinions of its own, independent of those of the constituent societies.

Society Organization and Function

Dean Teare, Chairman of the Committee on Society Functions, was invited to attend the Executive Board meeting, since the Board had decided to devote this meeting to thinking ahead in problems relating to the Society organization and function. Dean Teare presented a progress report on the preliminary thinking of the Committee. The main concern of the Committee is to study the Society operations with a view toward improving its organization and functioning. Dean Teare mentioned that the Committee has divided the main problem into four parts, assigned to subcommittees for study. The reports of the Sub-Committees will be carefully considered by the Committee on Society Functions either prior to or at the time of the Annual Meeting. It is expected that this study will carry on into next year.

Dean Teare enumerated the following factors which the Committee on Society Functions has under consideration:

1. *Diversity.* The Society organization has grown in many divergent directions and there seems to be need for a careful review of the Committee and Division Structure so as to achieve better coordination and minimize duplication of effort.

2. *Flow of ideas.* Many of the principal Society projects have been suggested by officers of the Society. Although some worthwhile projects have been initiated by Committees and Divisions, there is need for more activity in this direction. It has been suggested that if the Division and Section Chairmen are made members of the General Council, a closer working liaison would be established between the General Council and the operations in Divisions and Sections.

3. *Increasing the effectiveness of units of the Society.* The problem of increasing the operational effectiveness of the various Divisions, Committees, and Sections of the Society is being considered by the Committee. One of the principal problems seems to be that of travel expense. Experience has shown that Committees which meet at reasonable intervals achieve a higher degree of success and accomplishment than those which meet once a year at the Annual Meeting. On the other hand, travel appropriations can be costly, as pointed out by the fact that the travel expense of the other major engineering societies equals more than half the total ASEE Annual Budget.

4. *Size, composition, and function of the General Council and Executive Board.* This is a problem of studying the optimum organization and lines of administrative control with respect to the Divisions, Sections, and Committees in order to achieve close cooperation and efficient operation. The problem also consists of studying ways in which the most competent people can be inducted into Society activities and moved along into administrative positions.

5. *Service to the individual member.* This consists of a study of the scope of operations of the Society as it pertains to the benefits derived by the individual member. This problem is related to costs of operation, since the providing of extensive collateral services to individual members requires adequate Headquarter staff and increases the operational expense. A phase of this study will be that of the role of Summer Schools and Branches in the Society's program.

Dean Woolrich emphasized the dangers of embarking upon a program to pay travel expenses of Society members to attend Committee meetings, pointing out that most of the Societies have large travel budgets which consume a very substantial portion of the dues of the individual members. Once a travel budget has been expanded, it is virtually impossible to contact it.

The Secretary suggested that arrangements be made to hold meetings of ASEE Committees and Executive groups of the Divisions at the time of the Fall meetings of the ECAC and ECRC. These meetings have grown in importance and attendance and they could provide a common meeting ground for ASEE activities. This would give Committees and Divisions an opportunity to formulate their activities for the year and get off to an early start. This plan was approved in general principle by the Board.

One of the principal problems in the Society operation is that of getting the most competent people assigned to the principal Society functions. It was suggested that President Woolrich send a letter to the Chairman of Divisions urging them to give this matter careful consideration and to plan their nominations of Divisional officers sufficiently far in advance to make a careful study of the possible candidates and their qualifications.

In outlining the current operation of the Society, the Secretary stated that the Divisions, Committees, and Sections were allowed considerable latitude in their operations. The Secretary's office attempts to maintain a liaison between the various units and keeps them informed on major Society activities through the President's Newsletters, the JOURNAL and other media. The limited size of office staff makes it necessary to focus much of the attention on the principal Society projects and follow these through to maturity. An increase in office staff has been necessary in order to handle the rapidly growing activities of the Society. At present the secretarial staff is seriously overloaded and a further increase seems inevitable.

Dean Walker stated that there are a number of areas where the ASEE should take an active role in arranging conferences, such as instrumentation, electronic computers, etc.

The possibility of coordinating the program of the Section meetings with the national activities of the ASEE was discussed. This might be accomplished by arranging sub-groups in the various Sections which would cooperate with the Divisions and Committees of the Society, thus providing for a flow of ideas into the Sections as possible material for Section programs.

Dean Lampe advised against turning the Section meetings into a National meeting, stating that many of the Section meetings have a high degree of individuality and purpose of their own which might be destroyed by attempts to control from above.

The Executive Board discussed various proposals which have been advanced for improving Section operations by either relocating Section boundaries in order to shorten travel distances or by instituting Sub-Sections within the present frame-

work of the Sections of the Society. It is believed that a reduction of travel distances would increase attendance of the younger faculty members at Section meetings. This problem will be referred to the Sections for their consideration.

Dean Woolrich urged that each Section consider establishing a committee to develop relations with industry in its geographical area. The highly successful operations of the Division of Relations with Industry has demonstrated what can be done in this field of activity. The Relations with Industry Division has offered to cooperate with any Section of the Society in this type of operation.

It was pointed out that the Summer School programs might be improved by increasing the amount of time devoted to them, so as to make it possible to explore the curricular areas more deeply.

Dean Teare mentioned that one of the proposals under consideration by the Committee on Society Functions is that of electing the President one year in advance and having him serve as an ex-officio member of the Executive Board so as to be informed on current Society affairs. Also, the Committee on Society Functions has given some consideration to the possibility of a central nominating committee to suggest personnel for consideration as officers of Divisions and Sections of the Society.

Young Engineering Teachers' Paper Contest

The Secretary reported that most of the Sections had submitted entries in the Young Engineering Teachers' Paper Contest and that the Regional Judging Committees are making the semi-final selections.

ASEE Sponsorship of Education Conferences

The proposal of Vice President White for establishing an ASEE policy relative to sponsorship of Educational Conferences was presented to the Board. Briefly this policy would make it possible for the ASEE to endorse an engineering conference provided that:

1. it deals with engineering education,
2. it has responsible management,
3. there are no financial obligations to the Society,
4. one or more ASEE members are actively working on the planning committees.

The ASEE Executive Board would be given authority to approve ASEE sponsorship. This proposal will be referred to the General Council in June.

Fall Meetings of ECAC and ECRC

The Executive Board gave consideration to a possible theme for the Fall meeting of the ECAC-ECRC which will be held in conjunction with the ECPD Annual Meeting at the Statler Hotel, New York, October 15–17, 1953. One suggestion was that the ECAC and ECRC combine to develop a program on a general theme of the factors influencing creative thinking in engineering practice. No action was taken.

President Woolrich suggested that Dean Allen of CCNY be appointed as Chairman of the Fall meeting. The Executive Board approved.

Associate Institutional Membership

The Secretary stated that the Committee on Associate Institutional Membership, under the chairmanship of Jesse McKeon, is now contacting a large number of industries which have substantial engineering operations in order to expand the Associate membership in the Society. The Executive Board voted to accept the applications of the following companies for Associate Institutional Membership.

a) United Aircraft
b) ALCOA
c) IBM
d) Sandia Corporation
e) U. S. Steel
f) Institute of Paper Chemistry
g) Procter & Gamble

ECPD Appointment

A request from Dean Saville to appoint Professor Merryfield of Oregon State

College to succeed Professor Mockmore was approved by the Board.

Bank Resolution

The Executive Board voted in favor of a bank resolution permitting the Secretary to sign checks on a small petty cash account at the First National Bank in Evanston.

Respectfully submitted,

ARTHUR BRONWELL,
Secretary

College Notes

The George Washington University School of Engineering has announced that beginning next Fall it will offer a full curriculum leading to a Master of Engineering degree. This is the first time that such a program has been available at the University. Dean Martin Alexander Mason, of the School of Engineering, said that graduate degrees awarded under this plan would be in general engineering, not in any particular field. This, he said, is based on a policy to emphasize scientific principles and their application to engineering problems rather than to promote engineering as a particular art.

Present plans call for a division of the curriculum in three parts: one-half will cover up-to-date engineering problems; one-fourth will deal with mathematics; and one-fourth will be a review of modern principles of physics.

In the News

The Foundry Educational Foundation has announced that Mr. E. J. Walsh has become the Executive Director of the Foundation. The former Director, George K. Dreher, has joined the Waukesha Foundry Company as Manager of the Casting Division and a Director of the Company.

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Fourteen American geneticists have received grants from the **National Science Foundation** to attend the Ninth International Congress of Genetics in Bellagio, Italy, August 24–31, 1953. The awards were made from 120 applicants on the basis of their contribution to research in genetics. In making the selections, the National Science Foundation was guided by the recommendations of the Genetic Society of America.

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny	West Virginia University	April 17–18, 1953	C. H. Cather, West Virginia University
Illinois-Indiana	Rose Polytechnic Institute	May, 16, 1953	H. A. Moench, Rose Polytechnic Institute
Kansas-Nebraska	Kansas State College	Oct. 9–10, 1953	M. H. Barnard, University of Nebraska
Michigan	Detroit Institute of Technology	May 9, 1953	C. C. Winn, Detroit Institute of Technology
Middle Atlantic	University of Delaware	May 2, 1953	C. Bonilla, Columbia University
Missouri	Washington University	April 11, 1953	G. F. Branigan, University of Arkansas
National Capital Area	Howard University	May 9, 1953	L. K. Downing, Howard University
New England	University of Vermont	Oct. 10, 1953	E. T. Donovan, University of New Hampshire
North Midwest	Marquette University	Oct. 9–10, 1953	A. B. Drought, Marquette University
Ohio	University of Cincinnati	May 2, 1953	H. K. Justice, University of Cincinnati
Pacific Northwest	Washington State College	April 24–25, 1953	J. P. Spielman, Washington State College
Pacific Southwest	San Jose State College	Dec. 29–30, 1953	C. M. Duke, University of California at Los Angeles
Rocky Mountain	University of Colorado	April 11, 1953	C. A. Hutchinson, University of Colorado
*Southeastern	North Carolina State College		D. V. Terrell, University of Kentucky
Southwestern	University of New Mexico	April 3 & 4, 1953	M. L. Ray, University of Houston
Upper New York	Rochester Institute of Technology	October, 1953	F. E. Almstead, State University of New York

Members of the Society are welcome at all Section Meetings

*** No Date Set.**

New Members

ALDERMAN, ALFRED A., Divisional Supervisor of Technical Training, Fisher Body Div., General Motors Corp., Detroit, Mich. K. A. Meade, E. L. Yates.

BAIRD, HOLLIS S., Instructor in Physics, Northeastern University, Boston, Mass. C. D. Johnson, W. T. Alexander.

BALDWIN, BRUCE B., Associate Professor of Mechanical Engineering, University of Cincinnati, Cincinnati, Ohio. H. K. Justice, J. W. Beatty.

BAUM, ROBERT M., Physicist-Engineer, Sylvania Electric Products, Inc., Newton, Mass. K. L. Horowitz, R. B. Leng.

BENNETT, JAMES L., Instructor in Engineering, Junior College of Kansas City, Kansas City, Mo. H. O. Croft, C. M. Wallis.

BIEHL, JOHN F., Mechanical Engineering, University of Cincinnati, Cincinnati, Ohio. P. K. Johnson, H. P. Rodes.

BIGNELL, JAMES F., Acting Professor of Engineering Drawing, University of Tampa, Tampa, Fla. W. J. Luzadder, J. N. Arnold.

BIRD, JAMES P., Instructor in Engineering, Junior College of Kansas City, Kansas City, Mo. H. O. Croft, C. M. Wallis.

BLEAKLEY, WILLIAM B., Assistant Professor of Petroleum Production Engineering, University of Tulsa, Tulsa, Okla. W. L. Nelson, R. L. Langenheim.

BOGHOSIAN, WILLIAM H., Moore School of Electrical Engineering, University of Pennsylvania, Philadelphia, Pa. H. Sohon, J. R. Warren, Jr.

BOURNE, HENRY C., JR., Assistant Professor of Electrical Engineering, Massachusetts Institute of Technology, Cambridge, Mass. C. E. Tucker, K. L. Wildes.

BOYAJIAN, ARAM, Consulting Engineer, 55 Stratford Ave., Pittsfield, Mass. C. E. Tucker, G. S. Brown.

BROWN, SANBORN C., Associate Professor of Physics, Massachusetts Institute of Technology, Cambridge, Mass. W. R. Woolrich, R. B. Finch.

BUNTON, LAWRENCE O., Associate Professor of Textile Engineering, Texas Technological College, Lubbock, Tex. C. C. Perryman, O. A. St. Clair.

BUTHOD, ARTHUR P., Professor and Head of Petroleum Refining, University of Tulsa, Tulsa, Okla. R. L. Langenheim, J. C. Klotz.

CARTER, WILLIAM J., Associate Professor of Mechanical Engineering, University of Texas, Austin, Tex. M. C. Begeman, L. F. Kreisle.

CHANG, YI-CHUNG, Assistant Professor of Chemical Engineering, University of Tulsa, Tulsa, Okla. R. L. Langenheim, W. L. Nelson.

DAHLMAN, JOHN E., College Relations Representative, Glenn L. Martin Co., Baltimore, Md. F. W. Slantz, C. M. Merrick.

DAVIS, GEORGE E., Lecturer in Engineering Design, University of California, Berkeley, Calif. C. F. Garland, J. L. Meriam.

DAVIS, STEPHEN R., Instructor in Mechanical Engineering, University of Delaware, Newark, Dela. J. I. Clower, H. S. Bueche.

DOBYNS, SAMUEL W., Assistant Professor of Civil Engineering, Virginia Military Institute, Lexington, Va. R. A. Marr, Jr., J. H. C. Mann.

DURDEN, JOSEPH C., JR., Assistant Professor of Engineering Drawing and Mechanics, Georgia Institute of Technology, Atlanta, Ga. W. B. Ratterree, R. K. Jacobs.

DUWELIUS, THOMAS A., Assistant Professor of Civil Engineering, Rose Polytechnic Institute, Terre Haute, Ind. H. A. Moench, E. A. MacLean.

EATON, PAUL T., Associate Professor of Industrial Engineering, Georgia Institute of Technology, Atlanta, Ga. R. N. Lehrer, W. W. Cox, Jr.

EDGERTON, HAROLD E., Professor of Electrical Engineering, Massachusetts Institute of Technology, Cambridge, Mass. C. E. Tucker, K. L. Wildes.

FISHER, ROBERT A., Assistant Professor of Chemical Engineering, University of Denver, Denver, Colo. A. E. Paige, M. P. Capp.

FOSTER, DONALD V., Assistant Professor of Industrial Electricity, Pennsylvania State College, State College, Pa. E. A. Walker, K. L. Holderman.

FOSTER, EDWARD, Associate Professor of English, Georgia Institute of Technology, Atlanta, Ga. W. R. Woolrich, A. B. Bronwell.

FYFE, IAN M., Instructor in Mechanical Engineering, University of Delaware, Newark, Del. (Home: 201 S. Swarthmore Ave., Swarthmore, Pa.). J. I. Clower, R. V. Canning.

GANZER, VICTOR M., Associate Professor of Aeronautical Engineering, University of Washington, Seattle 5, Wash. J. B. Morrison, R. H. Smith.

GIET, GEORGE R., Professor of Electronics, U.S.N. Postgraduate School, Monterey, Calif. R. S. Glasgow, C. V. O. Terwilliger.

HANNAH, HORACE W., Associate Professor of English, Drexel Institute of Technology, Philadelphia, Pa. R. C. Disque, C. A. Kapp.

HARTWIG, WILLIAM H., Assistant Professor of Electrical Engineering, University of Texas, Austin, Tex. R. D. Slonneger, W. F. Helwig.

HEDRICK, J. E., Professor of Chemical Engineering, Cornell University, Ithaca, N. Y. J. C. Smith, F. H. Rhodes.

HENNEBERG, WALTER, Associate Professor of English, Drexel Institute of Technology, Philadelphia, Pa. H. R. Bintzer, R. S. Hanson.

HETTINGER, MATHIAS, Assistant Professor of Engineering, University of Buffalo, Buffalo, N. Y. P. E. Mohn, F. P. Fischer.

HIRTHE, WALTER M., Instructor in Mechanical Engineering, Marquette University, Milwaukee, Wis. J. E. Schoen, A. B. Drought.

HOAG, J. BARTON, Head, Science Department, U. S. Coast Guard Academy, New London, Conn. S. L. Smith, E. R. Rivard.

HOBGOOD, ALTON A., Assistant Professor of English, Georgia Institute of Technology, Atlanta, Ga. B. L. Brown, E. Foster.

HORTON, HORACE R., Assistant Professor of Electrical Engineering, Missouri School of Mines, Rolla, Mo. C. J. Grimm, J. B. Butler.

HUFSTEDLER, ROBERT S., Instructor in Chemistry, Colorado School of Mines, Golden, Colo. W. H. Dumke, R. A. Baxter.

JACKSON, KENNETH B., Professor and Head, Applied Physics, University of Toronto, Toronto, Ont., Canada. K. F. Tupper, A. Wardell.

JENKINS, LEO B., JR., Instructor in Electrical Engineering, University of Louisville, Louisville, Ky. M. G. Northrop, H. T. Smith.

JENSEN, MAX A., Associate Professor of Agricultural Engineering, State College of Washington, Pullman, Wash. J. Roberts, E. B. Moore.

JOHNSON, EDWARD F., Instructor in English, Newark College of Engineering, Newark, N. J. J. H. Pitman, J. T. Shaweross.

JONES, LLEWELLYN E., Assistant Professor of Mechanical Engineering, University of Toronto, Toronto, Ont., Canada. L. S. Lauchland D. G. Huber.

KENNEDY, JOHN J., Instructor in Civil Engineering, The Citadel, Charleston, S. C. J. C. Key, J. Anderson.

KIESELBACH, DAVID J., Educational Specialist, U. S. Air Force, Hayward, Calif. C. A. Rumble, W. W. Van Skiver.

KORTH, HENRY, Instructor in Mechanical Technology, L. I. Agricultural and Technical Institute, Farmingdale, N. Y. W. L. Rogers, D. W. Allee.

KRUGER, FRED W., Associate Professor of Mechanical Engineering, Valparaiso, Ind. H. C. Hesse, C. G. Peller.

LESSARD, ROGER, Associate Professor of Mathematics, Ecole Polytechnique, Montreal, Canada. H. Gaudefroy, C. R. Godin.

LINDBERG, ROY A., Assistant Professor of Mechanical Engineering, University of Wisconsin, Madison, Wis. C. A. Gilpin, P. H. Hyland.

MAINI, WILLIAM L., Instructor in Building Engineering and Construction, Massachusetts Institute of Technology, Cambridge, Mass. W. C. Voss, W. H. Gumpertz.

MARSHALL, THOMAS A., JR., Secretary, Engineers' Joint Council, 29 West 39th St., New York 18, N. Y. Thorndike Saville, A. B. Bronwell.

MARTINEZ, JOSE E., Assistant Professor of Civil Engineering, University of New Mexico, Albuquerque, N. M. W. C. Wagner, R. Foss.

MATTE, ANDREW L., Associate Professor of Electrical Engineering, Polytechnic Institute of Brooklyn, Brooklyn, N. Y. C. C. Whipple, W. A. Liswer.

MENKES, SHERWOOD B., Lecturer in Mechanical Engineering, City College of New York, New York, N. Y. G. J. Bischof, A. L. Steinhauser.

MICHAELS, ALAN S., Assistant Professor of Chemical Engineering, Massachusetts Institute of Technology, Cambridge, Mass. W. R. Woolrich, A. B. Bronwell.

MOON, GEORGE D., Instructor in Chemical Engineering, University of Cincinnati, Cincinnati, Ohio. H. K. Justice, C. Wandmacher.

MORGAN, NEWLIN D., JR., Associate Professor of Civil Engineering, University of Wyoming, Laramie, Wyo. H. T. Person, E. J. Lindahl.

NEWTON, GEORGE C., JR., Associate Professor of Electrical Engineering, Massachusetts Institute of Technology, Cambridge, Mass. C. E. Tucker, G. S. Brown.

O'BRIEN, ROBERT G., Personnel Representative, Johns Hopkins University, Applied Physics Laboratory, Baltimore, Md. C. E. Tucker, C. L. Townsend.

OORTHUYS, HENDRIK J., Assistant Professor of Electrical Engineering, Purdue University, Lafayette, Ind. L. E. Beck, C. R. Nichols.

OROWAN, EGON, Professor of Mechanical Engineering Massachusetts Institute of Technology, Cambridge, Mass. C. R. Soderberg, A. L. Townsend.

PADIS, LEO A., Assistant Professor of Mechanical Engineering, Virginia Polytechnic Institute, Blacksburg, Va. E. D. Harrison, J. B. Jones.

PEARSON, JAY F. W., President, University of Miami, Coral Gables, Florida. J. H. Clouse, C. E. Anderson.

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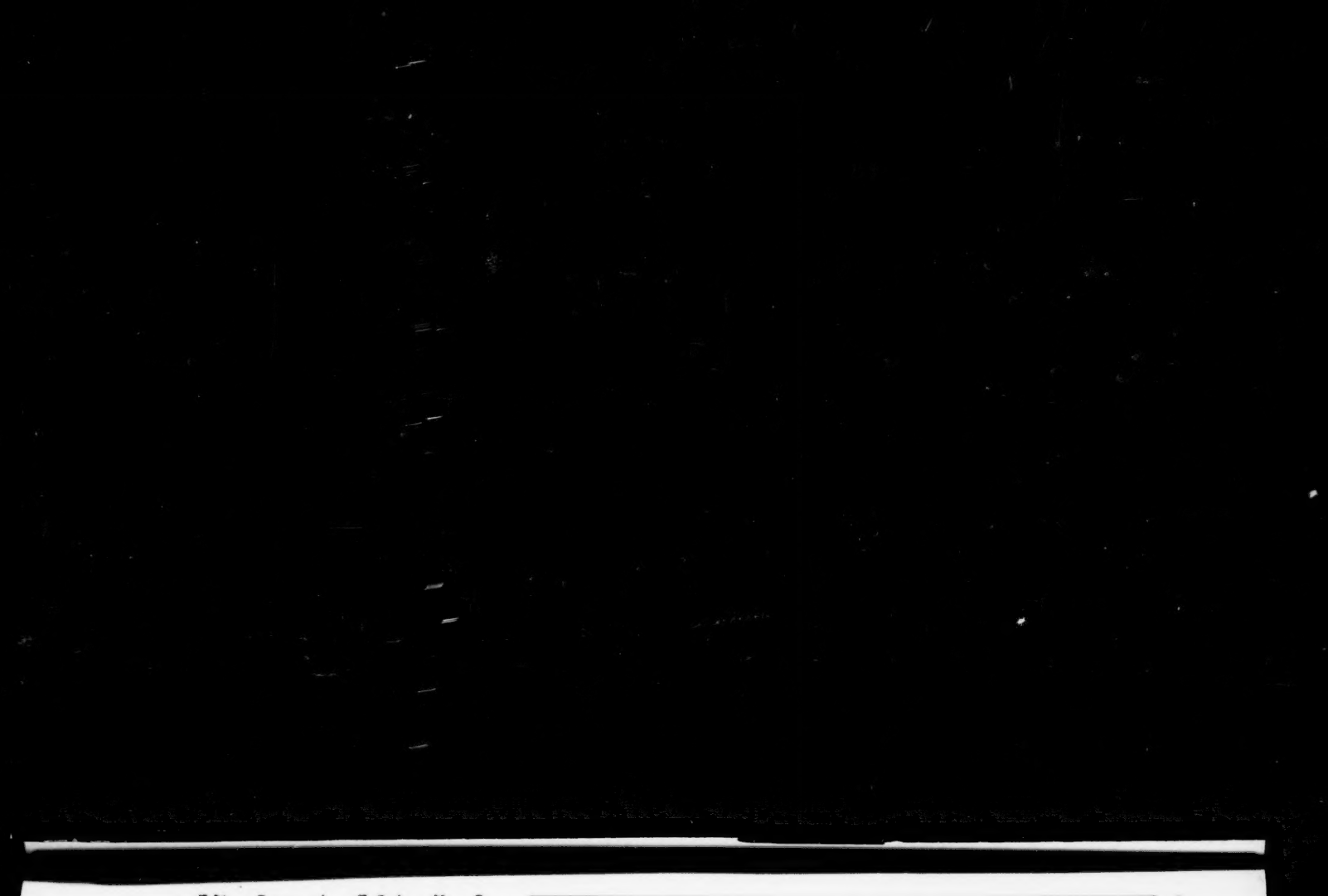

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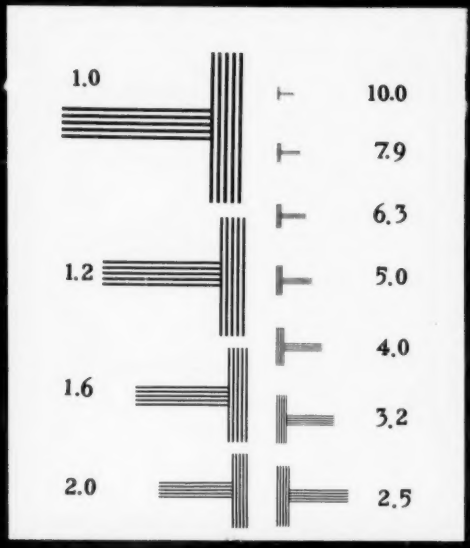

100 MILLIMETERS

INSTRUCTIONS Resolution is expressed in terms of the lines per millimeter recorded by a particular film under specified conditions. Numerals in chart indicate the number of lines per millimeter in adjacent "T-shaped" groupings.

In microfilming, it is necessary to determine the reduction ratio and multiply the number of lines in the chart by this value to find the number of lines recorded by the film. As an aid in determining the reduction ratio, the line above is 100 millimeters in length. Measuring this line in the film image and dividing the length into 100 gives the reduction ratio. Example: the line is 20 mm. long in the film image, and $100/20 = 5$.

Examine "T-shaped" line groupings in the film with microscope, and note the number adjacent to finest lines recorded sharply and distinctly. Multiply this number by the reduction factor to obtain resolving power in lines per millimeter. Example: 7.9 group of lines is clearly recorded while lines in the 10.0 group are not distinctly separated. Reduction ratio is 5, and $7.9 \times 5 = 39.5$ lines per millimeter recorded satisfactorily. $10.0 \times 5 = 50$ lines per millimeter which are not recorded satisfactorily. Under the particular conditions, maximum resolution is between 39.5 and 50 lines per millimeter.

Resolution, as measured on the film, is a test of the entire photographic system, including lens, exposure, processing, and other factors. These rarely utilize maximum resolution of the film. Vibrations during exposure, lack of critical focus, and exposures yielding very dense negatives are to be avoided.